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OTHER MATTERS

Space debris: status of work in Germany

Working paper submitted by Germany

INTRODUCTION

The scientific/technical analysis of space debris-related problems is conducted in Germany mainly at the Institute for Space-flight Technology and Nuclear Reactor Technology of the Technical University of Braunschweig (IFRR/TUBS), under contract from the German Space Agency (DARA).

The present paper provides a review of the current work and of some main conclusions to be drawn at the present time.

I. COLLISION RISK WITH SPACE DEBRIS

The collision risk posed by the increasing amount of orbital debris has been recognized world wide as a serious threat to space-flight activities. With larger structures and longer mission times, the collision probability may amount to several per cent and has become therefore an important design factor, especially for the planned Space Station. Hence, scientists in the United States of America, 1/ Europe, 2/ Japan 3/ and other countries are investigating these problems and the National Aeronautical and Space Administration (NASA) and the European Space Agency (ESA) have established working groups on orbital debris. 4/, 5/

Besides the 7,000 or so larger catalogued objects there are probably 70,000 to 140,000 objects larger than 1 cm in Earth orbits. Altogether, it has to be assumed

that several hundred thousand up to a million objects larger than 1 mm are orbiting in space. In view of the high velocities in the order of 10 km/s at which collisions take place, even such millimetre-sized objects will penetrate the outer walls of satellites.

II. MATHEMATICAL MODELS FOR SPACE DEBRIS AND EXISTING DATA GAPS

A detailed knowledge of all man-made space objects orbiting the Earth has become important for present and future space flights.

It is essential to know their size and mass distribution and their inclination distribution in order to assess the collision risk for any new launch, to design shields against small particle flux and to study the feasibility of collision avoidance manoeuvres 6/, 7/, 8/, 9/ for special cases. These are especially important tasks in connection with manned space flights.

A mathematical model describing the distribution of debris in space and also capable of predicting the future development and the effectiveness of countermeasures is currently being developed, improved and compared to other such models under development in other countries. Any model must be supported by a sufficient number of measurements in order to fit the theory to reality.

This has already been done for objects larger than 10 cm using orbital elements supplied by NASA, but for the smaller size range knowledge is very incomplete. Since also for smaller particles, especially in the millimetre range, there are several mechanisms of generation and orbital behaviour (see below), more measurement data are urgently needed.

III. THE NEED FOR ADDITIONAL MEASUREMENTS

The task of closing the a.m. data gaps can be performed only in the long term by the evaluation of in situ space experiments or material retrieved from space, e.g. the long-duration exposure facility (LDEF) surface.

Since the capabilities of ground-based tracking systems are limited to certain object size regimes and orbital altitudes, sensor systems located on board spacecraft may gain importance. Such sensors (optical, infrared, radar, etc.) can provide more detailed information on space debris objects smaller than 10 cm at any orbital altitude chosen. But the development and operation of on-board sensor systems for space debris measurements and the subsequent data evaluation procedures are very complex and costly tasks, especially since only a broad programme of measurements seems to be appropriate to gain a better understanding of space debris. Hence a well-prepared effort by all space-faring nations seems to be required.

IV. FRAGMENT GENERATION BY COLLISIONS IN SPACE

At the moment, the collision risk is probably dominated by fragments from explosions in Earth orbits. In the future, interactive collisions in the altitude regions around 1,000 and 1,500 km could become the main source for the generation of fragments endangering also the lower altitudes as a result of the rain-down effect.

The following example shows how large the amount of fragments generated and hence the pollution of the Earth's environment from collisions really is. According to the well-established formula for the mass distribution of collision fragments, a catastrophic collision of two objects with a total mass of 5,000 kg will generate up to:

600 objects above 10 cm (trackable)

50,000 objects in the cm range

8.5 million objects in the mm range

1.5 billion objects in the 1/10 mm range

The objects above 1 cm are the most dangerous, because they cannot be shielded. The objects in the cm and mm range can be shielded, but only with costly countermeasures. And even the collision with a submillimetre particle will cause surface erosion and is dangerous to vulnerable equipment, e.g. solar cells, antennas and sensors and for astronauts performing extravehicular activities (EVA).

V. SPECIAL CONSIDERATIONS FOR VERY SMALL PARTICLES (MILLIMETRE AND 0.1 MILLIMETRE SIZE RANGE)

Since particles of this size range can penetrate sensitive equipment, destroy solar cells and erode surfaces, they must also be contained in a space debris model. Large amounts of such small particles are generated not by explosions in space but rather by collisions, that means by the rather frequent impact of millimetre- or centimetre-size objects on larger structures (e.g. spent satellites) or by collisions between two large objects. This latter event happens very seldom in space; one has actually been recorded in the past and another is likely to have happened.

The small particles generated in such events have normally rather short lifetimes because, owing to their small mass-to-area ratio, the retarding aerodynamic forces are large. Especially in low circular orbits, these particles descend very quickly. For example, at 500 km altitude, most particles cannot survive more than one month. At higher altitudes, say 800 km to 1,000 km, the particles remain in space for two to five years, but even then their contribution to the overall debris flux at low altitudes (say for the Space Station at 500 km altitude) would be rather low.

However, all space-exposed surfaces brought back from orbit show a high number of small particle impacts corresponding to high flux values. According to our research work, this high flux is caused by particles in eccentric orbits. The perigee of these particles may be between 300 km and 500 km, the apogee between some 1,000 km and the geostationary altitude.

The particles in such eccentric orbits traverse all altitudes in the LEO region and therefore contribute to the flux. They have also a lifetime that is sufficiently long to accumulate to high flux values.

The high eccentricity of such debris particles can be explained by their generation process or by the eccentricity of their mother satellite or it can be induced by the impact energy. It seems that a large proportion of the small particle flux is due to elliptical orbits (unlike the majority of the larger debris objects), which would influence the angular and velocity distribution, shielding design and possible countermeasures.

VI. LONG-TERM THREAT: A CHAIN-REACTION OF COLLISIONS

Beyond the problems of single impacts, there is a long-term threat to space flights in general: a possible chain-reaction of collisions. The fragments generated by a collision between two larger objects in Earth orbits could produce new collisions and this can successively lead to the formation of an artificial debris belt in the way of a chain-reaction. Space flights could then become impossible at certain altitude regions for many centuries. This threat, pointed out for the first time by Kessler and Cour-Palais in 1978, 10/ has recently been analysed in more detail by several authors. 11/-16/

A collision risk of about 20 per cent per year among an assumed current population of about 35,000 objects larger than 1 cm in Earth orbits could be established. The risk for a catastrophic collision, i.e. with the total destruction of the target and a significant generation of objects large enough to produce catastrophic collisions again, was found to be in the order of 3.7 per cent per year. The collision risk will basically rise with the square of the number of objects. But only the larger objects, as potential sources for the generation of a large number of fragments by collision, are decisive for setting off a chain-reaction. Therefore the avoidance of smaller objects, such as explosion fragments or mission-related objects, as helpful as this would be to reduce the collision risk in the near future, will not prevent a chain-reaction of collisions.

A steady increase in the population will always lead to a chain-reaction of collisions. The critical population of larger objects for setting off a chain reaction has perhaps already been reached at certain altitude regions 16/ or will be reached within the next few decades, if space-flight activities are continued as in the past. 14/

Hence, in order to avoid the generation of too many debris fragments endangering space-flight activities or especially to avoid a chain-reaction of collisions, it is necessary to limit or preferably to reduce the number of larger

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objects in Earth orbits. The constant population level finally reached should be as low as possible to minimize fragment generation by collision, endangering all space-flight activities, e.g. the planned International Space Station. Space is a unique resource of all mankind and the problems concerning space debris will only be solvable as a world-wide joint venture.

VII. PREVENTIVE MEASURES

Preventive measures are absolutely preferable to limit the population to an uncritical level and should be established as soon as possible. Subsequent active removal is always much more difficult and expensive. Examples for effective preventive measures are:

- (a) Active de-orbit of payloads and upper stages at the end of their missions, especially important for higher orbits, e.g. those planned for ARIANE 5;
- (b) The elimination of intentional explosions in Earth orbits, or at least their limitation to very low altitudes;
- (c) The avoidance of unintentional explosions, e.g. by venting residual propellants in spent rocket upper stages;
- (d) The avoidance of operational debris, e.g. separation bolts, clamp bands, lens covers, etc.;
- (e) The avoidance of microparticles from surface degradation, e.g. paint of rocket upper stages.

Therefore a basically new way of performing space-flight activities must be established at the higher altitudes, where the self-cleaning effect of the Earth's atmosphere is missing. All objects brought into Earth orbits must be actively removed after the end of their missions, e.g. by an active controlled re-entry manoeuvre, and no debris should be left behind in orbit.

Indeed, for the next generation of the European launcher, ARIANE 5, it is planned to remove the central stage from orbit shortly after the separation of the payload by a controlled braking thrust.

VIII. ACTIVE REMOVAL OF DEBRIS FROM ORBIT

However, if it is not possible to limit the population, especially of the larger objects, in time, i.e. within the next few decades, active removal is the only way to reduce an unacceptable or critical high population level. Therefore it could become necessary in the future to remove objects already in orbit by special missions. To obtain an appreciable effect only the active removal of numerous larger objects from higher altitudes is reasonable.

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Hence a basically new strategy for the economical removal of numerous larger objects from Earth orbits called the tethered remover satellite (TERESA) has been developed at IFRR/TUBS. 17/, 18/ This strategy of a cycle consisting of energy transfer and energy transformation with the help of a space tether will be investigated in more detail in the near future in cooperation with NASA and industry.

Besides the purely technical problems, some political, legal and economical problems must be clarified before the removal of spent satellites and rocket upper stages can be started:

- (a) Where does the ownership and the responsibility for the debris object lie?
- (b) Is it permitted to remove foreign debris objects endangering space-flight activities?
- (c) Who has to bear the costs for any necessary removal manoeuvres:
 - (i) An international fund replenished by some kind of "space refuse removal assessment" on the owners;
 - (ii) Those responsible for the debris?

Nevertheless the engineering development of possible concepts for the removal of numerous larger objects from Earth orbits should be started immediately, because it will take another 10 to 20 years until such a remover vehicle will be operational in orbit.

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INFORMATION ON OPPORTUNITIES FOR PREPARATORY TRAINING OF
SCIENTIFIC RESEARCH WORKERS IN THE USSR AND STIPENDS
AVAILABLE FOR THE PURPOSE OF EXPANDING COOPERATION IN
THE PEACEFUL USES OF OUTER SPACE

Working paper submitted by the USSR

I. List of educational and scientific research institutions in
the USSR which have expressed willingness to participate in
international educational cooperation

1. Moscow State University (Lomomovskiy University) (MSU).
2. Moscow State University Shternberg State Astronomy Institute (SHAI MSU).
3. Bauman Moscow State Technical University (MSTU).
4. Moscow Aviation Institute (MAI).
5. Moscow Energy Institute (MEI).
6. Special Construction Office of Moscow Energy Institute (SCO MEI).
7. Moscow Timber Technology Institute (MTTI).
8. Leningrad Mechanical Institute (LMI).
9. Kharkov State University (KHSU).
10. Kharkov Aviation Institute (KHAI).

11. Dnepropetrovsk State University (DSU).
12. Moscow Oil and Gas Institute (MOGI).
13. Moscow State University Scientific Research Institute for Nuclear Physics (SRINP MSU).
14. Leningrad State University (LSU).
15. Saratov State University (SSU).
16. Moscow Physical and Technical Institute (MPTI).
17. Moscow Aviation Technology Institute (MATI).
18. Moscow Institute of Geodetic Engineering, Aerial Photography and Cartography (MIGIAC).
19. Gorky Scientific Research Institute for Radiology (GSRIR).
20. Moscow Institute for Electronic Machinery (MIEM).
21. Kuibyshev Aviation Institute (KAI).
22. Tomsk Polytechnical Institute (TPI).
23. Kazan Aviation Institute (KAI).
24. "Orbit" Special Construction and Technology Office of Novocherkassk Polytechnic Institute ("Orbit" SCTO NPI).
25. Moscow Institute for Radio Technology, Electronics and Automation (MIREA).
26. Moscow Institute of Biotechnology (MIBT).

II. FIELDS AND NATURE OF COOPERATION OFFERED

1. Research and applied work in the fields of:
 - 1.1. Design of next-generation automated space apparatus for research on the sun and the planets of the solar system (MIA).
 - 1.2. Development of technology, equipment and instruments for assembly, mounting and repair of space objects in orbit and on other planets (MIA). Problems of orbital space stations and large-scale space construction (LMI).
 - 1.3. Design of satellite systems for active functioning of at least 10 years (MIA).

1.4. Design of automated space apparatus and systems, including construction from composite materials (LMI).

1.5. Methods of space research on natural resources on Earth (LSU, MIGEAC, GSRIR, KAI, MTTI, MOGI, MSU).

1.6. Remote sensing from space for ecological monitoring for environmental preservation of the Earth's surface (preparation of thematic natural maps of specific regions for different purposes: geological, geomorphological, soil, vegetation, etc.) and research on the evolution of solar bodies (Moon, Mars, Mercury, Venus) from the comparative planetological point of view (MSU, MTTI, MIGEAC, GSRIR, LSU, SSU, SCO MEI).

1.7. Development and construction of space systems for research on the Earth's atmosphere and surface for national economic purposes (MSTU).

1.8. Development of methods and means for ecological monitoring of the physical composition of the Earth's surface and atmosphere (high-level profiles of temperature, pressure and humidity, cloud composition, sea and ocean surface temperature, presence of oil pollution) on the basis of measurements from the Earth's surface and from aerospace platforms of spontaneous radiation from the Earth's surface by microwave wave-length range (GSRIR).

1.9. Environmental pollution from space apparatus - research on the dissemination and effect of pollutants in space and the atmosphere. Development of methods and equipment for detection of the dissemination of ecologically harmful products from rocket engine combustion in space and the atmosphere (MSTU).

1.10. Design of engines utilizing fuel with ecologically clean combustion products. Experimental research on combustion chambers in Earth conditions and experiments in outer space (MSTU).

1.11. Research on and development of closed gas-turbine motors (CGTM) utilizing solar, nuclear and radioisotope energy sources from future orbital stations, multi-purpose orbital apparatus and geostationary systems linked with interplanetary space apparatus (MUTU).

1.12. Space radiotechnology complexes and the construction of installations utilizing them (LMI).

1.13. Management of space materials, research on the effect of space factors on materials and construction (LMI, MPTI, MATI, MIAN, KAI, LSU, TPI).

1.14. Problems of the development of national economic production on the basis of the achievements of astronauts (LMI).

1.15. Research, development and construction of automated biotechnical apparatus and closed automated complexes for the production of new drugs and medical preparations in sustained microgravitational conditions (MSTU).

1.16. Astronomical research (SHAI MSU, KHSU).

1.17. Research on the ionosphere (KHSU).

1.18. Asteroid research (KHSU in cooperation with United States scientific organizations).

1.19. Construction of specialized simulators for off work and maintenance of the skills of spacecraft crews in real time ("Orbit" SCTO NPI).

1.20. Development of scientific and methodological bases of radio-astro-space metrology on the basis of radio interferometry from ultra-long sources (RULS) for space navigation, geodesy and time-coordination insurance (limb measurement (GSRIR)).

1.21. Research on the spectral, temporal and spatial characteristics of fluctuations of amplitude, phase and angle in ultra-short wave radio signals in the 0.1-10.0 ITT range after travel through atmospheric and ionospheric turbulence in polar, temperate and equatorial latitudes in order to predict the influence of turbulence on space systems in connection with the development of recommendations for space-linked systems at low angles to the horizon (GSRIR).

1.22. The use of low-power (1.0 BT) ionoprobes with continuous emission of specially modulated linear signals in the 1-60 NGT range aboard space apparatuses for the organization of transionospheric probes for the prediction and global control of natural and artificial ionospheric disturbances in order to construct adaptive systems for long-range KB and UKB links (GSRIR).

1.23. The conduct of experiments in space with electron-cluster instruments for the prediction of earthquakes, tornadoes and other atmospheric catastrophes (MIREA).

1.24. Research, development and testing in natural condition of powerful modular laser semiconductor measuring instruments for high-resolution optical space links and monitoring (MIREA).

1.25. Research on technological methods for the production of traditional forms of food for astronauts in space conditions (MIBT).

1.26. The development and production of systems for the ISZ "Meteor" and NOAA type reception of information for the daily charting of subsurface and surface water conditions, nightly measurement of water temperature, nightly regional charts of subsurface water temperature, normal ozone concentration, the water steam content and other characteristics of the atmosphere, and the measurement of selective atmospheric absorption for the determination of stratospheric temperatures (MPTI).

2. In addition, scientific contacts and the exchange of information could be carried out in the following areas:

- The development of new designs for large-scale space constructions, the principles of their construction, and the robotization of orbital collecting (MSTU);
- The dynamics, strength, and heat stability of the constructions, research in the field of the structural dynamics of space apparatus (MSTU);
- The development of new designs for space construction utilizing fabric and tape, balloons and probes for research on planetary atmosphere (MSTU);
- Research on the planning of automated planetary voyages; development of means of transport and robo-technological guidance systems (LMI);
- Research on the scientific bases for the manufacture of materials aboard spacecraft (MSTU);
- Research on the construction of space energy systems utilizing solar, nuclear and thermo-nuclear means (MSTU);
- Research in the field of laser space-link systems and multichannel space-based information systems (MSTU);
- Research on heat mass exchange processes and nozzle unit gasodynamics (MSTU);
- Research on fuel supply in conditions of weightlessness using coarse capillary equipment (NSTU);
- Research on meteorological and weather rocket design (NSTU).

3. Participation in carrying out international space programmes

3.1. The Shternberg State Astronomy Institute of Moscow State University has proposed a project in the field of space astrometry for the purpose of producing a high-detail catalogue of the coordinates (0.002 seconds of angle), parallaxes and independent movement of stars. SHAI MSU is interested in international cooperation on the "Lomonosov" project and prepared to consider scientific and technical proposals for cooperation within the framework of the project.

3.2. In recent years SCO MEI together with MEI and other State educational organizations of the USSR have taken an active part in the work of developing public education in the USSR in terms of the introduction of new information technology in the educational field under the interested observation of UNESCO.

3.3. The Special Design Office of the Moscow Energy Institute is prepared to design, launch and track specialized satellites for projects by foreign countries which do not possess their own appropriate base.

The mass of the satellites may range from 50 to 1,500 kg, depending on the orbit required; the orbits may be circular, at altitudes between 200 and 3,000 km, highly elliptical or geostationary at an altitude of 35,000 km. The foreign client's on-board equipment may be installed in any of three ways:

- On board a satellite manufactured and supplied by the client (with a guarantee of no unauthorized access), which will be launched by a Soviet carrier rocket and tracked from the Medvezh'e Ozero launch site;
- In the form of a payload (satellite) installed on a satellite platform manufactured in the USSR;
- In the form of a secondary payload installed on a Soviet satellite.

The foreign client's technical specialists may participate in all phases of the satellite's preparation, launch and subsequent control and guidance (from the Medvezh'e Ozero site), and in the data acquisition and processing.

3.4. The Special Design Office of the Moscow Energy Institute is prepared to carry out practical work on the implementation of international projects for the utilization of outer space using the launch sites and equipment belonging to the Institute.

3.5. At the Teaching and Scientific Museum of Physical Geography at Moscow State University, teaching and scientific work is carried out on the methodology for processing and analysing space information for use in physical geography and environmental sciences. The Museum has a sector on physical geography from space and rational utilization of nature in which technical facilities for processing video information are available. Classes are conducted with students of the Environmental Sciences Department using the technical facilities for processing video data, as well as study classes with future astronauts enrolled at the Y. A. Gagarin Astronaut Training Centre.

The Physical Geography Museum at Moscow State University has accumulated a certain body of experience in training specialists in environmental and ecological studies which involve the use of space information. There is a proposal to establish in the museum a teaching and scientific centre on "Geodynamics and Physical Geography from Space" which would work in the interests of nature conservation, rational utilization of natural resources and ecology, and would also train Soviet and foreign specialists in thematic analysis of space information in physical geography.

3.6. The N. E. Bauman Moscow State Technical University is planning to conduct fundamental and research work on the problems of solar-laser power sources for converting extra-atmospheric solar radiation into laser-beam energy, transmitting it to ground receiving stations or other objects in space and converting it into

electrical current. These sources can be used both to solve the overall problems of energy supply on Earth and to deliver power to local objects in space and facilities on Earth.

It is proposed that co-operation in this area should be conducted on the following topics:

- Development of the concept of constructing solar energy stations in space to transmit power to Earth;
- Study of the physico-chemical processes of converting solar radiation energy into laser radiation and developing a mock-up laser with a solar pump;
- Developing a physical model and investigating thermal emission plasma-optical converters for transforming laser radiation into electrical current.

3.7. The N. E. Bauman Moscow State Technical University is prepared to participate in international co-operation on the following topics: technology for the storage and utilization of drinking water in space, technology and instruments for using water as a structural or construction material and as a binder, modelling of the dynamics of phase transitions in three-phase jets and back-condensation onto a cold surface, and discharge of water into space on board space objects. Theoretical and experimental studies under ground conditions and experiments in space can be conducted.

3.8. The Moscow State University is engaging in a large body of research related to the study of outer space and space experiments in the following fields: high-speed aerodynamics, software for powerful computer systems, physics of space and cosmic rays, space astronomy, image processing in space research, space biology, use of space information for mapping, study and ecological assessment of the natural environment, etc.

3.9. The Nuclear Physics Research Institute of Moscow State University and the Nuclear Physics Section in the Physics Faculty are conducting a broad range of work on the experimental and theoretical study of physical processes:

- Experimental study of the chemical composition of primary cosmic rays (10^{12} - 10^{15} eV) on Soviet satellites and study of processes of their acceleration and propagation;
- Experimental and theoretical study of the radiation pattern and physical phenomena in circumterrestrial space which affect the operation of satellites' on-board systems;
- Experimental and theoretical studies of the chemical composition and acceleration and propagation processes of solar cosmic ray particles in interplanetary space;

- Study of the mechanisms of magnetosphere-ionosphere interaction, including indirect measurements in space.

The Nuclear Physics Research Institute of Moscow State University has the necessary experimental base (including for the conduct of satellite-born experiments), a high level of theoretical capability, and experience in training specialists in these areas of space physics.

III. TRAINING OF SPECIALISTS IN THE EDUCATION FIELD

1. A number of higher educational scientific institutions (Moscow State University, Moscow State Technical University, the Moscow Energy Institute, the Moscow Aviation Institute, the Leningrad Mechanical Institute and others) can provide training for foreign post-graduate and undergraduate students and specialists in fields that contribute to the conduct of work on the utilization of outer space for peaceful purposes, send specialists and students to study in foreign higher educational institutions and also offer the possibility of exchanging specialists and young scientists to undergo training and improve their qualifications at foreign scientific centres.
2. The Moscow State Technical University considers that the most practical type of interaction, which will make it possible to pave the way for contacts as to the training of specialists and the conduct of research, is exchange of specialists and post-graduate and undergraduate students.
3. The P. K. Shternberg State Astronomy Institute at Moscow State University is the basic institute for training undergraduate and post-graduate students of the Astronomy Department of the Moscow State University Physics Faculty. The Institute trains specialists in all branches of astronomical science. It is interested in developing cooperation on astronomy with foreign institutes of higher education and scientific centres. It is prepared to accept every year two or three foreign graduate students and trainees specializing in astronomy and space research.
4. The Special Design Office of the Moscow Energy Institute has from the time of its establishment in 1948 been developing and producing electronic systems and equipment for space research; over the years, the Institute has acquired great experience in this area, as well as experience in the training of relevant specialists.

The Institute can render substantial assistance in the conduct of international cooperation on the study and utilization of outer space and the organization of professional training and education in this field.

The Institute has a staff of highly qualified workers who in addition have experience in teaching at the Institute, and some of them are able to give classes in English. The technical equipment of the Institute and its branches affords the possibility of conducting practical studies and research work at the most modern level.

In addition, the presence at the Medvezh'e Ozero branch of space communications equipment means that direct communication lines can be organized there which can be used to establish full-time information exchange channels with similar organizations abroad.

5. Organization of an international teaching centre on the basis of the Medvezh'e Ozero branch of the Special Design Office of the Moscow Energy Institute.

5.1. Topics of educational, practical and research work:

- means and methods of investigating remote outer space;
- means and methods of investigating planets, their satellites and comets within the solar system;
- means and methods of satellite tracking, guidance and control;
- space technology hardware and software;
- history of the development of space research technology.

5.2. Number of foreign students (with accommodation at the Medvezh'e Ozero branch hotel) - up to 35 at any one time. As this activity expands, the number of students could be increased, depending on financing (for the construction of a new hotel).

5.3. Classes can be conducted year round and/or in the form of short courses lasting 10-15 days.

5.4. If similar centres are established based at other organizations or abroad, instruction can be given under general programmes with constant exchange over space communication channels.

6. Organization of international scientific and technical seminars on issues relating to the study of outer space at the Medvezh'e Ozero branch of the Institute. (The subjects, conditions for holding the seminars and number of foreign participants accommodated at the branch's hotel are as indicated in sections 5.1-5.4 above.) Seminars can also be conducted addressed to an international audience, using direct space communication channels.

7. Conduct of international summer science schools for teachers and students under the general programmes and jointly with the American Space Academy (ASA), the American Space Society (ASS), the American Institute of Aeronautics and Astronautics (AIAA), the Flight Control Centre, the Cosmonaut Training Centre in Zvezdny Gorodok, etc.

8. The Moscow State University could consider proposals for study by foreigners in the following subjects:

- (1) High-speed aerodynamics;
- (2) Aerospace simulators;
- (3) Computer diagnosis and processing of images in space research;
- (4) Development of software for powerful computer systems;
- (5) Experimental and theoretical studies of physical processes in outer space;
- (6) Training of biologist-astronauts to conduct embryological experiments on board orbital stations;
- (7) Space astronomy.



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COMMITTEE ON THE PEACEFUL
USES OF OUTER SPACE
Scientific and Technical Subcommittee
Twenty-eighth session
Agenda item 5

IMPLEMENTATION OF THE RECOMMENDATIONS OF THE SECOND
UNITED NATIONS CONFERENCE ON THE EXPLORATION AND
PEACEFUL USES OF OUTER SPACE

Information on opportunities in the USSR for education, training,
conduct of scientific research and receipt of scholarships for
the purpose of expanding cooperation in the peaceful uses of
outer space

Working paper submitted by the USSR

Addendum

OFFERS BY EDUCATIONAL INSTITUTIONS AND SCIENTIFIC RESEARCH
INSTITUTES OF THE MINISTRY OF EDUCATION OF THE USSR AND THE
MINISTRY OF NATIONAL EDUCATION OF THE BYELORUSSIAN SSR OF
COOPERATION IN THE PEACEFUL USES OF OUTER SPACE

1. The A. M. Gorky Kharkov State University

The University offers to cooperate in the conduct of research on:

- Astronomy;
- Improvement of observations of space objects (use of holographic telescopes);
- Investigations of circumterrestrial outer space and radio-wave propagation;

- Experimental nuclear physics.

Training and improvement of specialists' qualifications in these fields:

- Search for planets and stars using space technology;
- Thematic mapping of the surface of planets (including the Earth) for physical and environmental studies.

The Kharkov State University and the astronomical observatory attached to it are cooperating with specialists from the United States of America, Italy, Poland, Finland and Sweden.

The University's astronomical observatory is participating in the International Solar Observation Programme, in determining the parameters of the Earth's rotation and in the international programme for observation of the coordinates of disputed stars.

For conducting investigations of circumterrestrial outer space and radio-wave propagation, as well as for training specialists in this field, a modern scientific and technical base has been established at the Kharkov State University, centring on a radiophysical observatory where a number of radiotechnical systems are available. Work is being completed on putting into operation a multipurpose ultra-high frequency unit for sounding the atmosphere and the ionosphere. Mobile units are available for conducting measurements by the vertical and Doppler sounding methods. Measurements can also be carried out on board scientific research ships.

In this area of activity, the Kharkov State University is in a position to participate in international programmes and joint international experiments, including investigations of the environment through active experiments in outer space. Joint experiments can be conducted both in the USSR and abroad (including experiments involving the use of equipment developed at the University).

The following activities are proposed for inclusion in international programmes:

- Modernization of existing and development of new instrumentation packages for routine diagnosis of the parameters of circumterrestrial outer space by radiophysical methods;
- Development of new methods for diagnosis of the parameters of the ionosphere;
- Theoretical and experimental studies of the mechanisms whereby perturbations are generated and propagated from sources of various kinds.

The Kharkov State University trains specialists with a broad grounding in astronomy, as well as specialists in nuclear physics and cosmic-ray physics, radiation physics and space radio physics.

There is a graduate school for Soviet and foreign nationals. The University offers to exchange specialists and post-graduate and undergraduate students for the purpose of conducting joint activities and improving their qualifications.

2. The S. Ordzhonikidze Moscow Aviation Institute

The Applied Mechanics and Electrodynamics Research Institute and the Cosmos International Science Teaching Centre of the Moscow Aviation Institute are active in scientific research and education in the field of space technology. Proposals have been drawn up for the construction of the Sadko automatic spacecraft, based on the Phobos spacecraft, to study microgravitation and materials science, conduct spectral observations of the Earth's surface and atmosphere to provide data for use in environmental sciences, meteorology and agriculture, and study circumterrestrial space and Sun-Earth linkages. Steps have been taken, inter alia through UNESCO, to internationalize the work on this project and attract foreign funding.

The Cosmos International Science Teaching Centre organizes international aerospace summer schools and lecture courses for Soviet and foreign specialists, and is preparing together with Eurospace for the conduct of the "Soviet-American Space Industry Dialogue" seminar in April 1991.

The Aviation Institute puts forward proposals for the organization of an international consortium to build and operate the Sadko specialized automatic spacecraft, and for the establishment on the basis of the Applied Mechanics and Electrodynamics Institute and the International Science Teaching Centre of a Cosmos International Space Technology Research Centre. The forms of international cooperation should preferably include work on joint projects and experiments, exchange of undergraduate and post-graduate students and trainees, organization of international seminars and conferences and training of specialists in space technology at the Cosmos Centre.

3. The Moscow Energy Institute

The offers of participation by the Moscow Energy Institute in cooperation in the field of training in the study and utilization of outer space relate to the concretization of participation by the Institute's main departments, which have experience in scientific research on the exploration and use of outer space and the training of specialists at different levels, with the possibility of utilizing the Institute's facilities to resolve problems of cooperation.

Organization jointly with the experimental and design office of an international teaching centre.

Topics of the teaching, practical and research work (in addition to those indicated in proposals by the Institute's Special Design Office for the work of the international teaching centre) are:

- Power supply for spacecraft;
- Electrical equipment for spacecraft;

/...

- Radio communications for spacecraft;
- Navigation;
- Guidance of spacecraft;
- Heat exchange;
- Construction of spacecraft;
- Use of space techniques for organizing knowledge centres and data banks;
- Instruction methodologies using space communications.

The Institute offers to hold, jointly with its Special Design Office and international space organizations, science schools for teachers and students under the general programmes at the Institute's Firsanovka Pioneer Camp, Energiya Sanatorium, Alushtu Sports Centre and Medvezh'e Ozero, Kalyazin and Alushtu testing grounds.

It also offers to participate in the organization of international technical and methodological seminars and schools on issues relating to the investigation and use of outer space for peaceful purposes.

Note: The international seminars and schools can be organized so as to make use of direct space communications.

Participation in international projects and programmes for the use of outer space is possible through the use of the Institute's Special Design Office testing grounds as well as by assigning specialists from the Design Office and the Institute itself as instructors and trainees in foreign scientific centres and institutes on an exchange basis.

4. Lenin Byelorussian State University

The proposal envisages work on the construction of next-generation space systems for research on the Earth's natural resources and surveillance of the status of the environment, including the training of specialists in specific problems, in part within the framework of international cooperation.

Work is now being carried out at the Byelorussian State University on the development of new technologies for next-generation space systems, on laser-spectrum diagnosis and investigation of the optical characteristics of the environment and natural formations. Specialists are being trained in these subjects. The work is being carried out in the Departments of Quantum Radio Physics and Optical Electronics and in the laboratories of the Scientific Centre for Remote Sensing of the Earth's Natural Resources of the Byelorussian State University.

/...

The basic areas covered by the planned work are as follows:

- Development of light reflectors on the basis of mirror-symmetrical geometry and the development of full navigation systems on that basis;
- Development of light-reflecting panels with the required light-reflection indicators and modulators with a rotating polarization plane, decreasing the weight and dimensions of light-reflecting panels installed on space objects and increasing the axial force of the reflected light;
- Development of the principles of broad-band spectroscopy of surface and remote sensing of the Earth based on the physical phenomena of elastic Raman scattering of light and the luminescence of objects in the environment;
- Development of systems of mobile modular apparatus (designed to operate in mobile ground and on-board aerospace systems) with high space and time resolution.

5. A. N. Sevchenko Scientific Research Institute for Applied Physical Problems of the Byelorussian State University

The Institute has acquired a good deal of experience in the development of remote methods for investigating the environment and in the construction of optical-range aerospace spectrographic equipment.

Microprocessor videospectropolarimetric systems of the "Gemma" series have been used successfully over a number of years aboard the "Mir" scientific orbital station and in laboratories on board aircraft and helicopters. The equipment has also been used in international experiments with the "FIFE-89" land surface climatology satellite in the state of Kansas in the United States.

Joint research could be conducted on the following topics:

- Development and construction of videospectropolarimeter aerospace systems for observing and monitoring the state of the environment;
- Metrological certification in aerospace surveying systems and the development of specialized means of high-accuracy calibration of spectrographic equipment;
- Development of methods for atmospheric correction of videospectropolarimeter data from spacecraft and aircraft and the methodology for determining the optical and physical parameters of the atmosphere and the surfaces beneath it;
- Development of effective methods of determining from space the character, physical parameters and degree of man-made alteration of the environment (aerosol discharges into the atmosphere, condition and degree of pollution of vegetation cover, water, etc.);

/...

- Development of methods for the optimal use of videospectrographic information and the creation of joint thematic aerospace data banks.

The results of the joint work on the topics enumerated above can be utilized effectively in setting up a full-time ecological station in orbit, on board the "Mir" scientific orbital station, and in solving the problems of global observation of the environment from high-orbit satellites.

Cooperation is also possible within the framework of the current international programmes of UNEP and MAB.

6. Byelorussian State University Scientific Research Institute for Physico-chemical Problems

Precision measurements of the chemical composition and dynamics of gases in near and deep space and in the vicinity of space planes are of practical interest, opening up new possibilities for predicting the global environmental consequences of human technological activity, increasing the operating reliability of space technology and clarifying the fundamental laws of the evolution of stellar and planetary systems.

The Institute proposes joint research on one of the promising ways of improving equipment for the contact analysis of rarified gases in space, which involves the use of gas sensors - promising new analytical instruments whose operating principle is based on recording the changes that occur in the electrophysical characteristics of the regions close to the surface of a semiconductor when molecules of the gases to be analysed are absorbed. These instruments combine sensitivity and resolving power (both for types of neutral molecules and ions, and in terms of their kinetic energy, including the ultra-weak range) with exceptionally small dimensions and low power consumption. At present these possibilities are only beginning to be realized, in view of the inadequacy of our knowledge of the complex physico-chemical processes taking place on the surface of the primary semiconductor devices involved in their technology and functioning.

Basic lines of joint work:

It is proposed that the results obtained in this research be developed and the corresponding technology worked out for the development of a range of semiconductor gas sensors and analysers designed to detect rarified gases and rarified molecular currents in a vacuum with a sensitivity of up to 10^{-13} Pa equivalent equilibrium pressure; on the basis of such instruments, specialized instrumentation packages need to be developed to solve the following scientific and applied space problems:

- Description of the chemical content, direction and speed of neutral molecules and ions of specific components of the "natural" gas medium of near and distant outer space ("molecular astronomy"), including the parameters of the outer atmosphere of planets and their satellites, of asteroids, and of the neutral components of the solar wind and the interstellar gas;

/...

- Analysis of the evolution of the trajectories and other parameters of artificial molecular probes;
- Environmental monitoring of near space;
- Analysis of the characteristics of space planes' own external atmosphere, highly sensitive external control of the gas and/or water-tightness of compartments of space planes and containers for process gases and liquids;
- Development of new autonomous navigational instruments for space planes based on measurement of the parameters of the gas envelope.



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MATTERS RELATING TO LIFE SCIENCES, INCLUDING SPACE MEDICINE

Methods based on the results of research in space biology and medicine

Working paper submitted by the Soviet Union

As the technology for manned space flight develops, space medicine is accumulating a considerable amount of knowledge with regard to man, his potential, health maintenance and ways of intervening in the process of adapting the body to the different conditions of space. Every space flight is achieving impressive results and furthering our knowledge. The attainments of space medicine are being used to improve health care not only in space but also on Earth.

Research into tapping the potential of space flight to improve health care and therapy is being pursued in various fields.

Reference may be made firstly to the transmission of all kinds of medical information. In order to monitor the physical condition of astronauts, a variety of methods and instruments has been developed to record and transmit to Earth by telemetry various physiological and biochemical parameters indicating the condition of various bodily systems. These enable doctors to be more or less fully informed of the state of health of astronauts who are hundreds of kilometres distant in space.

The principles of this remote diagnosis, or remote medicine, have many applications on Earth, for example, diagnosis or consultations by specialists in the case of patients far from major medical centres.

Reference may also be made to the application of experience gained from space flight to Earth medicine through the use of methods and instruments developed for

the selection and training of astronauts and for medical research in space. It should be noted that medical instruments designed to be used on board spacecraft are characterized by their small size, simplicity of operation and high degree of reliability.

1. The Argument apparatus is employed to scan the heart and major blood vessels by means of ultrasound. This makes it possible to examine the heart from the inside and to determine the condition of its chambers and major blood vessels, as well as the functioning of the valves and cardiac muscle. This portable apparatus is also used in clinics and ambulances, which vastly increases the potential for specialized diagnosis of cardiovascular disease.

2. The polyvalent portable respirator, which permits extended ventilation of the lungs, treatment of atelectasia, and the active inhalation of medical aerosols and anaesthesia, is used in resuscitation procedures and may prove of general applicability in ambulances.

3. A very varied range of medical instruments developed for research in space is currently in use in Ecosan automated mobile technical laboratories, in which medical examinations are performed on the general population with a view to recording the functional status of the body and formulating recommendations for health care and improvement. At the same time, studies are being conducted of the ambient atmosphere to detect harmful chemical substances and prepare an ecological assessment of various regions. If a comprehensive assessment of changes in health levels is conducted on the basis of examinations of a sufficiently large number of individuals living in a given industrial sector, it is possible to determine with some precision the degree to which the environment is polluted, and thus prepare a health profile (a distribution of individuals in terms of state of health) and produce maps of the medical-ecological conditions in the sector in question.

The medical evacuation apparatus used at the capsule landing-site to conduct a preliminary examination of astronauts is adaptable for use in emergencies to provide on-site emergency medical care to victims of accidents or natural disasters. The apparatus comprises several inflatable modules, equipped with the most advanced medical instruments, including those developed for research in space. Field tests in the Far North (Cape Schmidt, Chukotka) and in the Kara-Kum desert have shown that it can be used in various geographical regions under extreme conditions.

For prophylaxis against changes in the intestinal flora of astronauts on long space flights, "Lactobacterin", an anti-bacterial agent developed from a new strain of *Liplantarum* 38 lactobacteria, is used. The strain is representative of the intestinal automicroflora of healthy human beings, is resistant to digestive fluids and enzymes, has exceptionally high adhesiveness and is highly antagonistic to disease-producing micro-organisms. The strain is compatible with anti-bacterial preparations widely used in medical practice. Preparations can be manufactured from the strain which lend themselves to the microbial lyophilization of active lacto-bacterial antagonists. The preparation is intended for the treatment of children and adults suffering from colitis of varying aetiologies, bacterial dysfunctions resulting from the use of antibiotics, sulphamide preparations and other causes, non-specific colitis, the prophylaxis of persons convalescing from

dysentery and colienteritis, and, in obstetrical-gynaecological practice, for sanitation of the genital tracts of women suffering from genital inflammation and for pre-natal preparation during pregnancy. The agent is harmless and non-toxic, and there are no contraindications to its use.

The cardiovascular research methods used in space can be successfully applied in the diagnosis and prophylaxis of cardiovascular disease on Earth. The use of such methods for discovery of initial functional changes opens the way to prognosis in the case of unfavourable changes and makes it possible to take timely prophylactic action.

Research on the complex methods for evaluating the functional conditions of vestibulo-oculomotor interaction makes it possible to obtain objective information on the nature of oculomotor reactions, which facilitates immediate evaluation of the condition of the subject's vestibular and central nervous systems and, on that basis, prediction of the subject's capacity to carry out his professional functions: the visual observation of objects in certain situations influenced by complicated additional optokinetic and vestibular factors. The method may have applications in aviation, space, transport, underwater activities and sports medicine. In clinical medicine, the method can be used in differential diagnosis of the impairment of vestibular functions in otolaryngology, neurosurgery and neurology.

Of even broader application to Earth use are the methods worked out in space medicine for the psychological selection and preparation of people for work in extreme conditions, and the selection of groups on the basis of psychological compatibility.

Lastly, the results of the study of man in space, in conditions of weightlessness, significantly extend and deepen our knowledge of human health. In fact, it may be said that it is thanks to space activity that medical knowledge has been deepened of the mechanisms of human spatial orientation, the structure and function of the vestibular apparatus, human biomechanics and metabolism, and the cardiovascular and central nervous systems.

A great deal of experience with international cooperation has been acquired in space medicine. Together with scientists from a number of countries, Soviet specialists have carried out various experiments on Earth and in space, and have worked out research methods and procedures. For example, biomechanical research has been carried out on Soviet orbital stations on the Czechoslovak "Plasma" and "Reflotron" devices (the Beringer-Manheim Company), and the French "Echograph" apparatus for ultrasound research on internal organs, and the Polish "Physiotest" apparatus has been used for functional tests with physical loads.

What is required now is to concentrate the efforts of international society on the areas of highest priority of space research and utilization, in order to avoid duplication of effort and the unwarranted dispersal of means and efforts. The positive trend apparent in international relations in recent years towards the deepening of mutual understanding and confidence between countries unquestionably makes possible the appearance of new forms of co-operation, including the creation

of international "space markets", of which the geographic area and the number of partners involved will steadily increase. The process of uniting mankind's efforts in the peaceful utilization of space is gaining strength. The important thing is that everything done in this area should be done for the welfare and health of mankind in space and on Earth.

From this point of view, international partners should certainly be interested in the proposals put forward by Soviet specialists in space medicine, particularly the scientists of the Institute for Medico-Biological Problems of the USSR Ministry of Health, the only institution dealing with the medical security of space flight and the study of the human being in various extreme circumstances. The Institute has acquired a great deal of experience with regard to autonomic life-support systems; the organization, preparation and construction of space experiments with various biological objects; the testing of medical apparatus; and various other matters.

Firms and organizations interested in co-operation with the Soviet Union in space biology and medicine may receive detailed scientific and technical information on the instruments, apparatus, methods and means worked out by Soviet space medicine to safeguard space flight. Inquiries should be directed to the Institute for Medico-Biological Problems of the Ministry of Health of the USSR.

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MATTERS RELATING TO REMOTE SENSING OF THE EARTH BY SATELLITES,
INCLUDING, INTER ALIA, APPLICATIONS FOR DEVELOPING COUNTRIES

THE THEME FIXED FOR SPECIAL ATTENTION AT THE 1991 SESSION OF
THE SCIENTIFIC AND TECHNICAL SUBCOMMITTEE

Application of space photography to the study and
forecasting of mineral and biological resources

Union of Soviet Socialist Republics: working paper

Over the past decade, the Soviet Union has gained considerable experience in the use of space photography to study natural resources and the environment. Initially, the study of mineral and biological resources was confined to the location of diverse geological structures and of various types of forests and agricultural areas. Subsequently, research involving use of spacecraft began to focus on forecasting those resources, which is of paramount practical importance.

To a considerable extent, this can be explained by the fact that a large volume of high-quality space materials has been obtained, among which photographs from automatic satellites of the Cosmos series are of particular interest. Space photographs at a scale of approximately 1:1,000,000 are taken simultaneously in the three bands of the spectrum (0.5-0.6 μm , 0.6-0.7 μm and 0.7-0.85 μm), and also on colour and spectrozonal film. With the aid of large-format synthesizers, synthesized images at a scale of approximately 1:200,000 are made from original 18 x 18 cm negatives. The methods of synthesis which highlight the important features of the natural environment of a scene are selected. Photographs at a scale of approximately 1:200,000 are taken on panchromatic or spectrozonal film. Such photographs have a resolution of 5-6 m, and up to 3 m for high-contrast objects, which is unparalleled in world practice. The size of the original

negatives is 30 x 30 cm, which makes it possible to cover approximately 60 km of an area. The great advantage of this type of photography is its wide field of view and great detail. The negatives can be used to produce photographs at a scale of 1:50,000 to 1:20,000 without sacrificing quality. A method has been developed for printing colour photographs from spectrozonal negatives using light filters which make it possible to obtain near-natural colours. When necessary, corrected photographs and digital photomaps are prepared; such photographs and maps ensure a high degree of geometric accuracy of the image of a scene and its conformity to the cartographic projection. A wide selection of photomaps at scales ranging from 1:1,000,000 to 1:25,000 are produced in conformity with standard map sheets.

In the study of mineral resources, several areas for the application of remote-sensing methods in the forecasting and identification of different mineral deposits have been defined; such methods fall under the general concept of analysis of space data for the study of mineral deposits, which includes lineament metallogeny, the study of ring-shaped mineral deposits, the detection of photographic anomalies around mineral deposit sites, the use of photo-interpretation data in computer forecasting systems, the interpretation of photographic anomalies for the identification of potentially oil- and gas-bearing structures, and the use of remote-sensing data in prospecting for building materials and other common minerals.

Lineament metallogeny is based on the use of space photographs to detect lineaments corresponding to highly fissured areas which are particularly prone to penetration by ore-bearing solutions.

The study of ring-shaped mineral deposits is based on the interpretation of various kinds of ring structures which influence the distribution of ore deposits.

The detection of anomalies around the mineral deposit sites is based primarily on the use of data obtained from multi-band space surveys and their synthesis.

In prospecting for ore deposits, photo-interpretation data are being more widely used in computer forecasting systems, among which the Region system is particularly widespread.

In prospecting for oil and gas, data from space surveys are used primarily in the regional and exploratory stages. In addition to the detection of the general structural characteristics of a terrain, space photographs are used to detect anomalies associated with potentially oil- and gas-bearing areas.

The Soviet Union has acquired a great deal of experience in the detection of various kinds of building materials, peat and sapropel with the aid of data obtained from space photography. In forecasting, use is made of the coincidence of such minerals with specific types of quaternary deposits and associated forms of relief.

In the forecasting of mineral resources, specialized maps, which rely heavily on remote-sensing data have been developed; they include geological, geological and mineralogical and structural maps.

In the Soviet Union, the principal and most promising uses of remote sensing for the rational use of biological resources and their evolution, taking due account of the needs of forestry and agriculture, are forest and agricultural mapping.

In the thematic mapping of forest resources, various forms of airborne and space photography are used, depending on the tasks to be accomplished:

- Multi-band photography (3-6);
- Black-and-white photography;
- Colour photography;
- Synthesized images.

In the study and mapping of forest resources, space data are used:

1. In photo-interpretation;
2. In ground studies;
3. In photo-interpretation in the field;
4. In airborne observation;
5. In compiling maps;
6. In planning.

The contemporary method of mapping of forest resources using space and airborne photography is based on the photo-interpretation of forest surveys, which is rather advanced in the Soviet Union; the techniques employed make it possible to determine not only the types of stands of timber but also their fullness and age, that is, to assess directly the size of biological resources.

With a view to promoting agricultural production, airborne and space photography is also used rather successfully in the compilation of thematic maps which reflect the current state and dynamics of land, water and vegetation resources. Such maps contain quantitative categories for assessing the natural resources under consideration, the degree of man-made desertification of natural landscapes, and the rationality of existing methods of agricultural production. Of principal importance in this series of maps are those which depict the current state and dynamics of agricultural areas as a whole and those which indicate land use, land-improvement activities and the desertification of agricultural lands. In addition to these maps, for every branch of agricultural production - animal husbandry, dry-farming and irrigated agriculture - interrelated series of maps are compiled which illustrate the diverse aspects of the current state of land, vegetation and water resources and the means for their optimum use.

Multi-band photography makes it possible to detect vegetation affected by insect pests or infectious diseases and to distinguish growing vegetation from vegetation which has completed its growth cycle.

The study of agricultural water supply conditions focuses on the photographic study of the distribution of underground water indicators.

In order to improve the quality of observations, work is carried out not only with photographs but also with positive film and double negatives. At present, stable forms and rather precise methodological principles for the use of remote-sensing photographic data in the compilation of diverse thematic agricultural maps have been developed.

On the whole, it can be said that the provisional methods of processing and interpreting aerospace information for the solution of specific tasks have been confirmed in the course of the comprehensive study and mapping of natural resources.

That work, which is based on the use of aerospace photographic information, has opened up new possibilities for the study and rational use of natural resources and their protection and reproduction, the prospecting of minerals, and the global assessment and forecasting of environmental conditions.

The Soviet Union's achievements in the area of remote sensing for peaceful purposes has led to the development of mutually advantageous international co-operation.

The organizations of the Main Office of Geodesy and Cartography of the USSR have concluded a number of long-term agreements on the provision of space photographs with firms and organizations of countries of North, Central and South America and the Near and Middle East. They also provide photographs upon request to the United Nations, in particular to the Food and Agriculture Organization of the United Nations.

In order to ensure the most effective use of data obtained from space surveys, the organizations of the Main Office of Geodesy and Cartography of the USSR provide consultation services and train foreign specialists in methods of processing and interpreting space data on natural resources.



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PROGRESS IN NATIONAL AND INTERNATIONAL SPACE ACTIVITIES
RELATED TO THE EARTH ENVIRONMENT, IN PARTICULAR PROGRESS
IN THE GEOSPHERE-BIOSPHERE (GLOBAL CHANGE) PROGRAMME

Union of Soviet Socialist Republics: working paper

This working paper, containing updated information on the implementation of the Almaz ("diamond") programme in the Soviet Union, is submitted as a supplement to document A/AC.105/C.1/L.165 of 2 March 1990.

In the first half of 1991, the Soviet Union will launch the Almaz-1 space station to study the Earth's natural resources and oceans and seas, monitor the environment and perform other tasks for the benefit of the economy. The station is equipped with following apparatus.

1. Synthetic aperture radar with:

- | | |
|-------------------|------------|
| - Resolution | 15-20 m |
| - Coverage: | |
| Land | 35-40 km |
| Sea | 100 km |
| - Field of sight: | 2 X 350 km |

2. Radiometrical equipment with a working range of 0.8 cm and 5 cm, with:

- | | |
|---|--|
| - Resolution | 10-30 km
(improved up to five times in
secondary processing) |
| - Coverage | 500 km |
| - Sensitivity | 0.3°C |
| - Accuracy in measuring
the temperature of the
underlying surface | 0.5°-1°C |

The following research programmes will be carried out on board the Almaz-1 station:

(a) A comprehensive programme to study the Earth's natural resources:

- Research for the solution of environmental problems and climate study;
- Study of oceans and seas.

(b) The Resurs-A comprehensive programme:

- Study of diverse natural and man-made formations with the aid of radiophysical equipment;
- Development of methods to study radar and super-high-frequency radiometrical information for general thematic mapping.

(c) The Okean-I programme - study of oceans and seas:

- Study of water-surface pollution;
- Study of sea-surface conditions;
- Determination of water-surface temperature;
- Determination of surface-wind speed and direction.

(d) The Poisk programme - study of the land surface:

- Study of the agro-ecological state and dynamics of agricultural areas;
- Determination of zones of filtration in land-reclamation works;
- Mapping of inhabited areas of the ground cover;

- Study of seismically active regions;
- Mapping of underwater phenomena;
- Study of diverse geological structures by remote-sensing methods.

(e) The Torcs programme - study of the ice surface:

- Study of the state of the ice sheets;
- Study of ice conditions with a view to ensuring safe navigation.

(f) The Briz programme - study of the ecological state of coastal areas of the sea surface and of internal bodies of water:

- Study of the ecological state of the water surface, the development of bioplankton and the composition and dynamics of pollution (including thermal pollution).

(g) The Geos-A programme - development of new remote-sensing techniques for geological and ecological research.

(h) The Aral comprehensive programme - study of the ecological state of the Aral Sea.

More than 20 Soviet and foreign organizations will participate in these programmes.

All interested States, their research organizations and firms, as well as scientists and specialists, are invited to take part in the research and experiments conducted on board the Almaz-1 space station. Moreover, foreign partners will have ample opportunity to use and purchase photographs of the Earth's surface taken by the equipment on board the Almaz space station.

Work is carried out on a commercial basis at reasonable rates for scientific research.

Proposals concerning joint efforts should be addressed to:

Doctor Gerbert A. Efremov
Science-Production Engineering Association
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USSR - 143952
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COMMITTEE ON THE PEACEFUL USES OF OUTER SPACE

DRAFT REPORT OF THE SCIENTIFIC AND TECHNICAL SUBCOMMITTEE ON THE WORK OF ITS TWENTY-EIGHTH SESSION

INTRODUCTION

1. The Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space held its twenty-eighth session at United Nations Headquarters from 19 February to 1 March 1991 under the chairmanship of Professor J. H. Carver (Australia).
2. Representatives of the following Member States attended the session: Argentina, Australia, Austria, Belgium, Benin, Brazil, Bulgaria, Burkina Faso, Cameroon, Canada, Chile, China, Colombia, Czechoslovakia, Ecuador, Egypt, France, Germany, Hungary, India, Indonesia, Iran (Islamic Republic of), Italy, Japan, Lebanon, Mexico, Mongolia, Netherlands, Nigeria, Pakistan, Philippines, Portugal, Romania, Sweden, Syrian Arab Republic, Turkey, Ukrainian Soviet Socialist Republic, Union of Soviet Socialist Republics, United Kingdom of Great Britain and Northern Ireland, United States of America, Uruguay, Venezuela, Viet Nam and Yugoslavia.
3. Representatives of the Department of Technical Cooperation for Development and the Office of Legal Affairs of the United Nations Secretariat and the Economic and Social Commission for Asia and the Pacific (ESCAP) also attended the session.
4. Representatives of the following specialized agencies attended the session: Food and Agriculture Organization of the United Nations (FAO), International Civil Aviation Organization (ICAO), World Meteorological Organization (WMO), International Atomic Energy Agency (IAEA) and United Nations Educational, Scientific and Cultural Organization (UNESCO).
5. Representatives of the European Space Agency (ESA), the International Maritime Satellite Organization (INMARSAT), the International Organization for Space Communications (INTERSPUTNIK), the International Telecommunications Satellite Organization (INTELSAT), the Council on International Cooperation in the Study and Utilization of Outer Space (INTERCOSMOS), the Committee on Space Research (COSPAR)

of the International Council of Scientific Unions (ICSU), the International Astronautical Federation (IAF) and the International Society for Photogrammetry and Remote Sensing (ISPRS) also attended the session.

6. A list of the representatives of Member States, specialized agencies and other international organizations attending the session is contained in document A/AC.105/C.1/INF/20.

7. At the opening of the session, the Subcommittee adopted the following agenda:

1. Adoption of the agenda.
2. Statement by the Chairman.
3. General exchange of views.
4. United Nations Programme on Space Applications and the co-ordination of space activities within the United Nations system.
5. Implementation of the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space.
6. Matters relating to remote sensing of the Earth by satellites, including, inter alia, applications for developing countries.
7. Use of nuclear power sources in outer space.
8. Questions relating to space transportation systems and their implications for future activities in space.
9. Examination of the physical nature and technical attributes of the geostationary orbit; examination of its utilization and applications, including, inter alia, in the field of space communications, as well as other questions relating to space communications developments, taking particular account of the needs and interests of developing countries.
10. Matters relating to life sciences, including space medicine.
11. Progress in national and international space activities related to the Earth environment, in particular progress in the geosphere-biosphere (global change) programme.
12. Matters relating to planetary exploration.
13. Matters relating to astronomy.
14. The theme fixed for special attention at the 1991 session of the Scientific and Technical Subcommittee: "Applications of airborne and satellite remote sensing for prospecting mineral and groundwater resources and for monitoring and managing biological resources, with

emphasis on agriculture, taking into particular account the needs of developing countries".

15. Other matters.

16. Report to the Committee on the Peaceful Uses of Outer Space.

Meetings and documentation

8. The Subcommittee held ... meetings.

9. A list of the documents which were before the Subcommittee is provided in annex I to the present report.

10. At the opening meeting, the Chairman made a statement outlining the work of the Subcommittee at its current session. He also reviewed the activities of Member States in the field of space exploration, including important advances that had been achieved as a result of international cooperation during the past year.

11. At the 386th, 388th and 391st meetings, the Chairman informed the Subcommittee that requests had been received from the permanent representatives of Greece, Spain, Cuba, the Libyan Arab Jamahiriya and Malaysia, as well as from the Permanent Observer for the Holy See, to attend the session. Following past practice, those delegations were invited to attend the current session of the Subcommittee and to address it as appropriate. This was without prejudice to further requests of that nature and did not involve any decision of the Subcommittee concerning status, but was a courtesy that the Subcommittee extended to those delegations.

12. General statements were made by the following delegations: Argentina, Australia, Austria, Bulgaria, Germany, India, Indonesia, Pakistan, Turkey, Ukrainian Soviet Socialist Republic, Union of Soviet Socialist Republics and United States of America. Statements were also made by the representatives of FAO, ESA, INMARSAT, INTERSPUTNIK, INTELSAT, COSPAR and IAF.

13. At the 386th meeting, the Chief of the Outer Space Affairs Division made a statement reviewing the work programme of the Outer Space Affairs Division. At the 388th meeting, the Expert on Space Applications made a statement outlining the activities carried out and planned under the United Nations Programme on Space Applications.

Technical presentations

14. In accordance with paragraph 7 (b) (vii) of General Assembly resolution 45/72 of 11 December 1990, a symposium on the theme "Applications of airborne and satellite remote sensing for prospecting mineral and groundwater resources and for monitoring and managing biological resources, with emphasis on agriculture, taking into particular account the needs of developing countries", sponsored by IAF and COSPAR, was held in two sessions. The first session of the symposium was chaired by Mr. George Ohring, Chairman of the COSPAR Commission on Space Studies of the

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Earth's Surface, Meteorology and Climate. It included presentations by Mr. James V. Taranik of the University of Nevada Desert Research Institute, United States, on "Applications of Remote Sensing for General Geology, Oil and Mineral Resources"; by Mr. Massimo Menenti of the Winand Staring Centre, the Netherlands, on "Applications of Remote Sensing for Water Resources"; by Mr. Lawrence C. Rowan of the United States Geological Survey, on "Applications of Remote Sensing for Mineral Resources"; and by Mr. Nicolay V. Mezhelovsky of the USSR Ministry of Geology, on "Remote Sensing: New Capabilities for the Study of Natural Resources". The second session was chaired by Mr. Dale Fester, Vice-President of IAF. It included presentations by Dr. Réjean Simard of the Canada Center for Remote Sensing, on "The Global Change Encyclopaedia: A Project for International Space Year"; by Mr. Roberto Pereira da Cunha of the Brazil Institute for Space Research, on "Applications of Remote Sensing for Deforestation"; by Mr. M. G. Chandrasekhar of the Indian Space Research Organization, on "Applications of Remote Sensing for the Management of Land Resources"; and Mr. Edwin I. Cissel of the United States Department of Agriculture, on "Applications of Remote Sensing for Agricultural Resources".

15. In accordance with paragraph 7 (b) (iv) of General Assembly resolution 45/72, COSPAR arranged a special presentation on "The International Geosphere-Biosphere Programme: The Challenge for Remote Sensing". The presentation was made by Mr. John Townshend of the Department of Geography of the University of Maryland, United States.

16. During the session of the Subcommittee, in addition to the COSPAR/IAF symposium, special scientific and technical presentations were made by Mr. Todd Hawley of the International Space University (ISU) on "Progress towards the permanent ISU campus in 1992"; by Mr. James Harford of IAF, on the 1992 COSPAR/IAF World Space Congress; by Dr. Wesley T. Huntress of the United States National Aeronautics and Space Administration (NASA), on "Voyage to the Planets"; by Astronaut Vance Brand of NASA, on the Space Shuttle programme; by Dr. Dan Tarpley of the United States National Oceanic and Atmospheric Administration (NOAA), on remote sensing; by Dr. Arnauld Nicogossian of NASA and Academician Oleg Gazenko of the USSR Institute of Medical and Biological Problems, on life sciences and space medicine; by Dr. Gunther Riegler of NASA, on "Access to Data from Space Astrophysics Missions"; by Mr. Sinichi Nakayama of the Japan Science and Technology Agency, on "Space Development Activities of Japan"; and by Ms. Diane Thompson of the Canadian Remote Sensing Society, on "Airborne Remote Sensing for Global Resource Monitoring".

Recommendations of the Scientific and Technical Subcommittee

17. After considering the various items before it, the Subcommittee, at its ...th meeting, on 1 March 1991, adopted its report to the Committee on the Peaceful Uses of Outer Space containing its views and recommendations as set out in the paragraphs below.

I. UNITED NATIONS PROGRAMME ON SPACE APPLICATIONS AND THE
CO-ORDINATION OF SPACE ACTIVITIES WITHIN THE UNITED
NATIONS SYSTEM

II. IMPLEMENTATION OF THE RECOMMENDATIONS OF THE SECOND
UNITED NATIONS CONFERENCE ON THE EXPLORATION AND
PEACEFUL USES OF OUTER SPACE

18. In accordance with General Assembly resolution 45/72, the Subcommittee continued its consideration of these items. In accordance with past practice, the Subcommittee considered the two items jointly.

19. The Subcommittee noted that the General Assembly, in paragraph 13 of resolution 45/72, had once again emphasized the urgency and importance of implementing fully the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82) as early as possible. The Subcommittee also took note of paragraph 8 of the same resolution, in which the General Assembly had stated that, in the context of the Subcommittee's consideration of the item, it was particularly urgent to implement the following recommendations:

"(a) All countries should have the opportunity to use the techniques resulting from medical studies in space;

"(b) Data banks at the national and regional levels should be strengthened and expanded and an international space information service should be established to function as a centre of coordination;

"(c) The United Nations should support the creation of adequate training centres at the regional level, linked, whenever possible, to institutions implementing space programmes; necessary funding for the development of such centres should be made available through financial institutions;

"(d) The United Nations should organize a fellowship programme through which selected graduates or postgraduates from developing countries should get in-depth, long-term exposure to space technology or applications; it is also desirable to encourage the availability of opportunities for such exposure on other bilateral and multilateral bases outside the United Nations system."

20. In response to the recommendations of the Working Group of the Whole to Evaluate the Implementation of the Recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space contained in its report on the work of its fourth session held in 1990 (A/AC.105/456, annex II, paras. 4, 5 and 6), endorsed by the General Assembly in paragraph 10 of resolution 45/72, the Subcommittee had before it the following documents: a report on international cooperation in the peaceful uses of outer space: activities of Member States (A/AC.105/470), containing information submitted by Member States in response to paragraphs 4 (c), 4 (j) and 6 (b) of the report of the Working Group; a list of experts in space technology and applications (A/AC.105/460 and Add.1), in response to paragraph 4 (e); a report on cooperative arrangements in support of the

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implementation of the United Nations Programme on Space Applications (A/AC.105/473), in response to paragraph 4 (f); a report on economic aspects of strengthening and expanding national and regional data banks and establishing an international space information service as a coordinating centre (A/AC.105/474), in response to paragraph 4 (m); a study on applications of space technology to flood monitoring and control (A/AC.105/472), in response to paragraph 5 (b) (iv); a report on upper atmosphere studies for weather and environment monitoring (A/AC.105/477), in response to paragraph 5 (b) (vii); a report on the implementation of the recommendations of UNISPACE 82: actions by international organizations (A/AC.105/475), in response to paragraph 6 (a). In addition, the Subcommittee had before it annual reports, including information in response to paragraph 4 (d), submitted by the following international organizations: the International Telecommunication Union (ITU) (A/AC.105/462), INMARSAT (A/AC.105/466), the European Telecommunications Satellite Organization (EUTELSAT) (A/AC.105/467), INTELSAT (A/AC.105/480) and INTERCOSMOS (A/AC.105/481).

21. In accordance with paragraph 9 of General Assembly resolution 45/72, the Subcommittee reconvened the Working Group of the Whole with a view to improving the execution of activities relating to international cooperation, particularly those included in the United Nations Programme on Space Applications, and to proposing concrete steps to increase such cooperation as well as to make it more efficient. The Working Group was chaired by Mr. Muhammad Nasim Shah (Pakistan); it held ... meetings between 21 and ... February 1991 and adopted its report (A/AC.105/C.1/...) on ... February 1991.

22. Having considered the report of the Working Group of the Whole, the Subcommittee decided at its ...th meeting, on ... February 1991, to adopt that report, as contained in annex II to the present report, on the understanding that the recommendations contained therein would be carried out in accordance with paragraph 9 of General Assembly resolution 37/90 of 10 December 1982. The Subcommittee recommended that the Working Group of the Whole be reconvened the next year to continue its work.

A. United Nations Programme on Space Applications

23. Regarding the expanded United Nations Programme on Space Applications, the Subcommittee had before it the report of the United Nations Expert on Space Applications (A/AC.105/478). The report was supplemented by the statement by the Expert. The Subcommittee noted that the Programme on Space Applications for 1990 had been carried out satisfactorily and commended the work accomplished by the Expert in carrying out the work programme as endorsed by the Subcommittee at its last session.

24. The Subcommittee noted with appreciation that since its last session additional contributions had been offered by various Member States and organizations and that they had been acknowledged with appreciation in paragraph 52 of the Expert's report, as well as under appropriate sections of the present report.

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25. In this connection, the Subcommittee continued to express its concern over the limited financial resources available for carrying out the Programme and appealed to Member States to support the Programme through voluntary contributions. The Subcommittee felt that the limited resources of the United Nations should be focused on the highest priority activities and noted that the Programme on Space Applications was the priority activity of the Outer Space Affairs Division.

1. 1990-1991

(a) Long-range fellowships for in-depth training

26. The Subcommittee expressed its appreciation to the Governments of Austria, Brazil, China and the USSR as well as to ESA for having offered the training fellowships for the period 1990-1991 that were currently being conducted, as shown in the annex to the Expert's report (A/AC.105/478). The Subcommittee noted with appreciation that the offers of fellowships were to be continued for 1991-1992 by the same Governments and organization, as indicated by the Expert in his statement.

27. The Subcommittee noted that it was important to increase the opportunities for in-depth education in all areas of space science, technology and applications through long-term fellowships.

(b) Technical advisory services

28. The Subcommittee took note of the technical advisory services provided by the Outer Space Affairs Division in support of regional space applications projects, as indicated in the report of the Expert (A/AC.105/478):

(a) Assistance to the Government of Costa Rica in the organization of the Space Conference of the Americas: Prospects of Cooperation for Development, held at San José from 12 to 16 March 1990;

(b) Participation, in cooperation with the European Space Agency, in a survey for the selection of sites for the acquisition of satellite data for remote sensing applications in African countries within range of ESA ground stations, as a follow-up to the United Nations/United Nations Development Programme (UNDP)/FAO/ESA Meeting of Experts on Remote Sensing and Satellite Meteorology Applications to Marine Resources and Coastal Management (see A/AC.105/436);

(c) Assistance to the Economic Commission for Africa (ECA) and the Governing Council of the Regional Centre for Services in Surveying, Mapping and Remote Sensing through participation in a fact-finding mission to the Regional Centre at Nairobi.

29. The Subcommittee also noted that the Division would assist the Centro de Levantamientos Integrados de Recursos Naturales por Sensores Remotos (CLIRSEN) of Ecuador in a survey of Member States within range of the Cotopaxi Remote Sensing Ground Receiving Station in order to provide those States with information on the services to be provided by the station.

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(c) United Nations workshops/training courses/seminars/meetings of experts

30. With regard to the activities of the Programme carried out in 1990, the Subcommittee expressed its appreciation to:

(a) The Government of Sweden for co-sponsoring the United Nations International Training Course on Remote Sensing Education for Educators, hosted by the University of Stockholm and the Swedish Space Corporation and held at Stockholm and Kiruna from 14 May to 15 June 1990 (A/AC.105/463);

(b) The Government of Cuba for co-sponsoring the United Nations Workshop on Space Communications for Development, hosted by the Ministry of Communications of Cuba and held at Havana from 26 to 30 March 1990 (A/AC.105/469);

(c) The Government of Brazil, as well as FAO and ESA, for co-sponsoring the United Nations/FAO/ESA Workshop on Microwave Remote Sensing Technology, hosted by the Instituto Nacional de Pesquisas Espaciais (INPE) at São José dos Campos from 19 to 23 November 1990 (A/AC.105/471).

31. The Subcommittee also noted that the United Nations, through the Programme on Space Applications, had co-sponsored and financially supported the United Nations/FAO International Training Course on Agricultural Applications of Remote Sensing, hosted by the Agricultural University of Prague from 18 to 29 June 1990, and the United Nations/FAO/ESA International Workshop on Remote Sensing: Geo-information Technology for Decision-Makers, co-sponsored by the Government of France and hosted by FAO at Rome from 7 to 16 November 1990.

32. The Subcommittee took note of the status of the 1991 programme of United Nations workshops/training courses/seminars/meetings of experts, which included the following activities, as described in paragraph 33 of the Expert's report (A/AC.105/478):

(a) The United Nations/ESA Workshop on Basic Space Research, to be organized in cooperation with the Government of India for the benefit of countries in the regions of the Economic and Social Commission for Asia and the Pacific (ESCAP) and the Economic and Social Commission for Western Asia (ESCWA) and to be held at the Indian Space Research Organization in Bangalore, India, from 30 April to 4 May 1991;

(b) The third United Nations/FAO/ESA Workshop on Microwave Remote Sensing Technology, to be organized in cooperation with the Government of Spain for the benefit of countries in the regions of ECA and ESCWA and held at the Instituto Nacional de Técnica Aeroespacial (INTA) ground station in Maspalomas, Canary Islands, Spain, from 10 to 14 June 1991;

(c) The fifteenth United Nations/FAO International Training Course on Remote Sensing Applications to Renewable Resources, to be organized in co-operation with the Government of Italy and held at FAO headquarters, Rome in September 1991;

(d) The International Training Course on Remote Sensing Applications for Environmental Assessment and Monitoring, to be organized in cooperation with the Government of the United States and held at the Earth Resources Observation System (EROS) Data Center in Sioux Falls, South Dakota, from 9 September to 4 October 1991;

(e) The United Nations/FAO/ECA Regional Seminar on Remote Sensing for Decision-Makers, to be organized in cooperation with the Government of Kenya and held at the Regional Centre for Services in Surveying, Mapping and Remote Sensing in Nairobi, from 17 to 21 June 1991;

(f) The United Nations Regional Workshop on the Application of Space techniques to Combat Natural Disasters, to be co-sponsored by the Office of the United Nations Disaster Relief Coordinator (UNDRO), WMO and UNESCO, in cooperation with the Government of China and ESCAP, for the benefit of countries in the ESCAP region, and hosted by the State Science and Technology Commission of China at Beijing from 16 to 20 September 1991;

(g) The sixth United Nations/FAO/WMO/ESA Training Course on the Applications of Remote Sensing in Agrometeorological and Hydrological Studies, to be organized in cooperation with the Government of Peru for the benefit of countries in the region of the Economic Commission for Latin America and the Caribbean (ECLAC) from 7 to 25 October 1991.

(d) Promotion of greater co-operation in space science and technology

33. The Subcommittee noted that during the thirty-third Plenary Meeting of COSPAR, held at The Hague in June-July 1990, the United Nations, through the Programme on Space Applications, had co-sponsored a special panel on the "Equatorial Electrojet and Related Phenomena" and provided financial support for a participant from a developing country, and that during the forty-first IAF Congress held at Dresden, Germany, in October 1990, the United Nations had co-sponsored a special session on "Space and Forest Management" and supported the participation of three speakers from developing countries.

34. The Subcommittee also noted that the United Nations, through the Programme on Space Applications, would co-sponsor the following activities: a Workshop on Space Technologies for Development, to be held at Montreal, Canada, from 2 to 5 October 1991, in conjunction with the forty-second IAF Congress; a special workshop at the 17th Congress of the International Society for Photogrammetry and Remote Sensing, to be held in Washington in August 1992; and a special workshop for developing countries, to be organized during the COSPAR/IAF World Space Congress to be held in Washington in August-September 1992.

2. 1992

United Nations workshops/training courses/seminars/meetings
of experts

35. The Subcommittee recommended the approval of the programme of workshops/training courses/seminars/meetings of experts proposed for 1992, as outlined by the Expert in paragraph 34 of his report (A/AC.105/478), including the following:

(a) A United Nations/United States International Conference on Satellite Remote Sensing for Resource Management, Environmental Assessment and Global Change Studies: Needs and Applications for the Developing World, to be held in Washington;

(b) The seventh United Nations/FAO/WMO/ESA Training Course on the Applications of Remote Sensing in Agrometeorological and Hydrological Studies, to be held at Nairobi;

(c) The second United Nations/Sweden Training Course on Remote Sensing Education for Educators, to be held at Stockholm and Kiruna, Sweden;

(d) An International Seminar on Satellite Communications, to be organized in cooperation with the Government of the USSR and held in Moscow;

(e) A United Nations/FAO/International Centre for Theoretical Physics (ICTP) training Course on Remote Sensing Applications, to be held in Rome;

(f) A United Nations Regional Communications Workshop, to be organized in cooperation with the Government of China, for the benefit of States in the ESCAP region;

(g) A United Nations/UNESCO/WMO/ICTP Conference on Bridging the Information Gap in Space Science and Technology, to be held at United Nations Headquarters.

B. International space information service

36. The Subcommittee noted with satisfaction that the Outer Space Affairs Division was in the process of developing an international space information system, including both information within the United Nations system and access to external databases. The Subcommittee took note of the report on the economic aspects of strengthening and expanding national and regional data banks and establishing an international space information service (A/AC.105/474), prepared by the Secretariat as requested by the Working Group of the Whole.

37. The Subcommittee noted with satisfaction the publication of the document entitled "Seminars of the United Nations Programme on Space Applications: Selected Papers on Remote Sensing Technology and Satellite Communications (A/AC.105/468) and the list of experts in space technology and applications (A/AC.105/460 and Add.1), as recommended by the Working Group of the Whole. It also noted that for 1992 the Secretariat would prepare updated editions of the Directory on Education, Training,

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Research and Fellowship Opportunities in Space Science and Technology and its Applications (A/AC.105/432) and the Directory of Information Systems on Space Science and Technology (A/AC.105/397/Rev.1 and Add.1).

C. Reports

38. The Subcommittee noted with appreciation the reports submitted to it in response to the recommendations of the Working Group of the Whole in its report on its fourth session (A/AC.105/456, annex II, paras. 4, 5 and 6). It noted in particular the technical studies prepared by the Secretariat on flood monitoring and control (A/AC.105/472) and on upper atmosphere studies for weather and environment monitoring (A/AC.105/477).

D. Co-ordination of space activities within the United Nations system and inter-agency co-operation

39. The Subcommittee noted that the General Assembly, at its forty-fifth session, had reaffirmed its request that all organs, organizations and bodies of the United Nations system and other intergovernmental organizations working in the field of outer space or on space-related matters should cooperate in the implementation of the recommendations of UNISPACE 82.

40. The Subcommittee noted with satisfaction that the twelfth Inter-Agency Meeting on Outer Space Activities had been convened by the Administrative Committee on Coordination (ACC) in Rome and hosted by FAO from 26 to 28 September 1990 and that its report (ACC/1989/PG/9) was before the Subcommittee. The Subcommittee took note of the information provided on the progress achieved in the coordination of space activities among organizations within the United Nations system and expressed its appreciation for the report of the Secretary-General entitled "Coordination of outer space activities within the United Nations system: programmes of work for 1991 and 1992 and future years" (A/AC.105/465).

41. The Subcommittee continued to stress the necessity of ensuring continuous and effective consultations and coordination in the field of outer space activities among organizations within the United Nations system and the avoidance of duplication of activities.

E. Regional and interregional mechanisms of co-operation

42. The Subcommittee noted that the General Assembly, in its resolution 45/72, had reaffirmed its approval of the recommendation of UNISPACE 82 regarding the establishment and strengthening of regional mechanisms of co-operation and their promotion and creation through the United Nations system. The Subcommittee noted with satisfaction that, in carrying out various activities in the implementation of recommendations of UNISPACE 82, the Secretariat had sought to strengthen those mechanisms.

43. The Subcommittee took note of the efforts undertaken as part of the United Nations Programme on Space Applications, in accordance with the UNISPACE 82 recommendation concerning the development of indigenous capabilities, to establish regional centres for space science and technology education in existing national or regional educational institutions in developing countries, as recommended by the Committee on the Peaceful Uses of Outer Space and endorsed by the General Assembly in resolution 45/72, and as outlined in paragraphs 35 to 44 of the report of the Expert (A/AC.105/478). The Subcommittee urged Member States to support the development of such regional centres. The Subcommittee requested the Outer Space Affairs Division to keep it informed of further developments on the subject.

44. The Subcommittee took note of the contributions made by other international organizations towards the promotion of international cooperation in outer space: FAO was continuing its activities relating to remote sensing of renewable natural resources, including training courses, support of development projects and monitoring environmental conditions for the FAO Early Warning System on Food and Agriculture; ITU was continuing its work in the international coordination of space communications, including planning the 1992 World Administrative Radio Conference, providing technical assistance to developing countries and assisting in the development of a regional communication satellite system for Africa (RASCOM); INMARSAT was continuing to develop its satellite communication system for maritime, land-mobile and aeronautical communications, including developing small, low-cost terminals and providing technical assistance and training; INTELSAT was further developing its system for international satellite communications, including its programme for training and education in the use of communication satellites; ESA was continuing its programme of international cooperative space activities, including training programmes for the benefit of developing countries, support of the activities of the United Nations Programme on Space Applications and technical assistance projects; and INTERSPUTNIK was continuing to develop its communication satellite system and its programme of assistance to developing countries through dissemination of information and assistance in Earth station development.

45. The Subcommittee emphasized the importance of regional and international cooperation in making the benefits of space technology available to all countries, through such cooperative activities as shared payloads, dissemination of information on spin-off benefits, ensuring compatibility of space systems and providing access to launch capabilities at reasonable cost.



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USES OF OUTER SPACE
Scientific and Technical Subcommittee
Twenty-eighth session

DRAFT REPORT OF THE SCIENTIFIC AND TECHNICAL SUBCOMMITTEE ON THE WORK OF ITS TWENTY-EIGHTH SESSION

Addendum

III. MATTERS RELATING TO REMOTE SENSING OF THE EARTH BY SATELLITES, INCLUDING, INTER ALIA, APPLICATIONS FOR DEVELOPING COUNTRIES

1. In accordance with General Assembly resolution 45/72, the Subcommittee continued its consideration of this item.
2. In the course of the debate, delegations reviewed the national and cooperative programmes in remote sensing. Examples were given of national programmes in developing and developed countries and of international programmes based on bilateral, regional and international cooperation, including programmes of technical cooperation between developing countries. Countries with advanced capabilities in the field, including some developing countries, described programmes to provide assistance to other developing countries.
3. The Subcommittee took note of the continuing programmes of China, France, India, Japan, the USSR and the United States for remote-sensing satellites as well as the planned remote-sensing satellite systems of Brazil, Canada and ESA. It also took note of the remote-sensing activities of FAO for mapping, assessment and management of renewable natural resources for the benefit of developing countries. The Subcommittee heard special presentations on remote sensing by experts from Canada, the Netherlands and the United States, as mentioned in paragraph ... of the present report.
4. The Subcommittee reiterated its view that remote-sensing activities should take into account the need to provide appropriate and non-discriminatory assistance to meet the needs of the developing countries.
5. The Subcommittee emphasized the importance of making remote-sensing data and analysed information available to all countries at reasonable cost and in a timely

manner. The Subcommittee also recognized the need for continuing free access to data from operational meteorological satellites.

6. The Subcommittee felt that international cooperation in the use of remote-sensing satellites should be encouraged, both through coordination of the operations of ground stations and through regular meetings between satellite operators and users. It noted the importance of compatibility and complementarity of existing and future remote-sensing systems. The Subcommittee also noted the importance of sharing experiences and technologies between developing countries, of cooperation through international and regional remote-sensing centres and of joint work on collaborative projects.

7. Recalling General Assembly resolution 41/65 of 3 December 1986, by which the Assembly had adopted the Principles Relating to Remote Sensing of the Earth from Outer Space, the Subcommittee recommended that at its twenty-ninth session it continue its discussion on remote-sensing activities conducted in accordance with those principles, during its consideration of the agenda item concerning remote sensing.

8. The Subcommittee recommended that the item be retained on its agenda as a priority item for the next session.

IV. USE OF NUCLEAR POWER SOURCES IN OUTER SPACE

9. In accordance with General Assembly resolution 45/72, the Subcommittee continued its consideration of this item.

10. The Subcommittee noted with satisfaction that, on the basis of the work of the Subcommittee and its Working Group on the Use of Nuclear Power Sources in Outer Space at its last session, the Legal Subcommittee's Working Group on the question had been able to agree on a text for draft principle 3 relating to guidelines and criteria for safe use (A/AC.105/457, annex I, para. 12).

11. The Subcommittee took note of a working paper submitted by the United States (A/AC.105/C.1/L.176) with a view to contributing further to the substantial progress made in the Subcommittee on the subject.

12. In this connection, some delegations expressed the view that, in the consideration of the draft principles, discussion of principle 3 should not be reopened at the current stage, and that work should continue on the remaining principles on which agreement had not yet been reached.

13. The Subcommittee also took note of the work being done in IAEA and other international organizations concerning international principles of radiation protection. The Subcommittee noted the importance of harmonizing principles relating to the use of nuclear power sources in outer space with other international principles and standards, including those of IAEA and other international organizations. The Subcommittee agreed that the scientific and technical guidelines and criteria for the safe use of nuclear power sources in outer space should, in the future, be reviewed and revised as necessary, as

provided in principle 12 of the draft principles contained in document A/AC.105/C.2/L.154/Rev.7.

14. The Subcommittee agreed that Member States should be invited to report to the Secretary-General on a regular basis with regard to national and international research concerning the safety of nuclear-powered satellites.

15. The Subcommittee agreed that further studies should be conducted on the problem of the collision of nuclear power sources with space debris and that the Subcommittee should be kept informed of the results of such studies. The view was expressed that an international expert group should be established to consider the problem.

16. The Subcommittee recommended that the item be retained on its agenda for the next session. The Subcommittee further recommended that the question of reconvening the Working Group on the Use of Nuclear Power Sources in Outer Space be considered by the Committee at its next session in the light of the work carried out by the Legal Subcommittee on the subject at its thirtieth session.

V. QUESTIONS RELATING TO SPACE TRANSPORTATION SYSTEMS AND THEIR IMPLICATIONS FOR FUTURE ACTIVITIES IN SPACE

17. In accordance with General Assembly resolution 45/72, the Subcommittee continued its consideration of this item. The Subcommittee heard a special presentation by a United States astronaut on the Space Shuttle programme, as mentioned in paragraph 16 of the present report.

18. The Subcommittee noted that 1991 was the thirtieth anniversary of the first human space flight.

19. In the course of the discussion, delegations reviewed the national and cooperative programmes in space transportation systems. In particular, the Subcommittee noted that:

(a) China had launched a communication satellite, the FY-1 meteorological satellite, and a recoverable satellite for remote sensing, life science and material science, as well as providing launches for the Asiasat commercial communication satellite and Pakistan's Badr experimental satellite. It had also continued developmental work on new models of the Long March series of launchers;

(b) Japan had launched a BS broadcasting satellite and the second Marine Observation Satellite (MOS) into Earth orbit, as well as launching the Muses spacecraft into a lunar trajectory to test precision orbit-control technology, data transmission systems and lunar swing-by procedures for use in future planetary missions. Japan had also continued work on new launchers;

(c) In 1990, the USSR had continued its very active programme of space flights. The year had seen the end of one long-duration flight aboard the Mir space station by two cosmonauts, the beginning of a new mission by two other cosmonauts, a short visit by a Japanese cosmonaut and the expansion of the station

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by the addition of the Kristall module for microgravity research and other space research. Throughout the year, astrophysical, geophysical, biological and medical experiments had been conducted aboard the station. Training for future missions had begun for cosmonauts from Austria, Germany and the United Kingdom. The USSR had also launched the Gamma astrophysical observatory and satellites in the Cosmos, Resurs-F, Raduga, Raduga-1, Gorizont, Molniya-1, Molniya-3, Meteor-2, Okean, Nadezhda and Foton satellites for space research, remote sensing, communications, meteorology, oceanography, search and rescue, and microgravity research. These satellites had been launched by Soyuz, Proton, Cosmos, Tsyklon, Molniya and Zenit launchers;

(d) The United States had continued work on the development of the International Space Station Freedom, in cooperation with Canada, Japan and ESA. Six Space Shuttle flights had taken place in 1990, launching the Hubble Space Telescope and the ESA Ulysses solar polar observer, carrying the Astro astronomical observatory, recovering the Long Duration Exposure Facility and conducting microgravity research. Other United States launch vehicles had launched the Combined Release and Radiation Effects Satellite for scientific research and two small Multiple Access Communication Satellites, as well as the Rosat X-ray observatory in cooperation with Germany, an Insat communication and meteorological satellite for India, a Marcopolo broadcasting satellite for the United Kingdom and communication satellites for Indonesia, the United Kingdom, Japan, INMARSAT and INTELSAT. Developmental work had continued on increasing the duration of Shuttle flights and developing advanced launchers, including the National Aerospace Plane;

(e) ESA had continued developmental work on the heavy launcher Ariane V, the space plane Hermes and the Columbus system, including elements provided for the international space station programme. The Ariane launcher developed by ESA had launched the Spot-2 remote-sensing satellite and the TDF broadcasting satellite for France and communication satellites for Germany, the United Kingdom, the United States, EUTELSAT and INTELSAT.

20. The Subcommittee noted the developments in various programmes related to space transportation and stressed the importance of international cooperation for providing all countries with access to the benefits of space science and technology.

21. The Subcommittee recommended that consideration of the item be continued at its next session.

VI. EXAMINATION OF THE PHYSICAL NATURE AND TECHNICAL ATTRIBUTES OF THE GEOSTATIONARY ORBIT; EXAMINATION OF ITS UTILIZATION AND APPLICATIONS, INCLUDING, INTER ALIA, IN THE FIELD OF SPACE COMMUNICATIONS, AS WELL AS OTHER QUESTIONS RELATING TO SPACE COMMUNICATIONS DEVELOPMENTS, TAKING PARTICULAR ACCOUNT OF THE NEEDS AND INTERESTS OF DEVELOPING COUNTRIES

22. In accordance with General Assembly resolution 45/72, the Subcommittee continued consideration of this item.

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23. In the course of the consideration of the item, some delegations expressed the view that the Subcommittee should contribute to the work of the Legal Subcommittee in its consideration of the question of the geostationary orbit.

24. Some delegations expressed the view that the geostationary orbit was a limited natural resource subject to saturation, that the existing technological and coordination procedures were not adequate, and that a special regime was required to ensure equitable access by all States, in particular by equatorial States and other developing countries. They felt that the roles of ITU and the Committee on the Peaceful Uses of Outer Space with respect to the geostationary orbit were complementary.

25. Other delegations expressed the view that questions relating to the geostationary orbit were being addressed effectively in ITU. They reviewed developments in national and international space communications programmes, which would contribute to ensuring that all countries would have access to satellite communications.

26. The Subcommittee took note of the various current and planned satellite communications programmes of Member States and of international organisations, including INMARSAT, INTELSAT and INTERSPUTNIK.

27. The Subcommittee recommended that consideration of the item be continued at its next session.

VII. MATTERS RELATING TO LIFE SCIENCES, INCLUDING SPACE MEDICINE

[To be included in A/AC.105/C.1/L.175/Add.2]

VIII. PROGRESS IN NATIONAL AND INTERNATIONAL SPACE ACTIVITIES RELATED TO THE EARTH ENVIRONMENT, IN PARTICULAR PROGRESS IN THE GEOSPHERE-BIOSPHERE (GLOBAL CHANGE) PROGRAMME

28. In accordance with General Assembly resolution 45/72, the Subcommittee continued its consideration of this item.

29. The Subcommittee noted with satisfaction that, at its invitation, COSPAR and IAF had arranged a special presentation to the Subcommittee on the International Geosphere-Biosphere Programme, as mentioned in paragraph 15 of the present report. The Subcommittee expressed its appreciation to COSPAR and IAF for the very informative presentation.

30. The Subcommittee noted the progress being made through international cooperation in the International Geosphere-Biosphere Programme. It noted that such a joint international effort was of fundamental importance for examining the future habitability of the planet and for managing the common natural resources of the Earth. The Subcommittee took particular note of the need to involve as many nations as possible in the scientific activities of the programme, both in

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developed and in developing countries. It agreed that it should remain informed of progress in the programme so as to be able to facilitate international cooperation in that area.

31. The Subcommittee noted the need for further research to reduce the uncertainties in data and models relating to temperature change, sea-level change, global vegetation cover, deforestation and other factors affecting the Earth environment. The Subcommittee recognised the important contribution that space activities could make to the study of the Earth environment.

32. The Subcommittee took note of the activities being planned as part of the Mission to Planet Earth programme. It noted, in particular, plans for the Almaz environmental monitoring system, the Priroda ecological module and the Earth Observing System for making comprehensive observations of the global environment. The Subcommittee also took note of the proposal for the Protection of the Environment for Assuring a Cleaner Earth (PEACE) satellite system, for a cooperative programme for tropical cyclone monitoring and for a satellite seismic monitoring system. The Subcommittee recommended that States consider participating in such cooperative activities.

33. The Subcommittee recommended that consideration of the item be continued at its next session.



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COMMITTEE ON THE PEACEFUL
USES OF OUTER SPACE
Scientific and Technical Subcommittee
Twenty-eighth session

DRAFT REPORT OF THE SCIENTIFIC AND TECHNICAL SUBCOMMITTEE ON THE WORK OF ITS TWENTY-EIGHTH SESSION

Addendum

VII. MATTERS RELATING TO LIFE SCIENCES, INCLUDING SPACE MEDICINE

1. In accordance with General Assembly resolution 45/72, the Subcommittee continued its consideration of this item. The Subcommittee heard special presentations on the question by experts from the USSR and the United States, as mentioned in paragraph ... of the present report. The Subcommittee took note of working papers submitted by the USSR (A/AC.105/C.1/L.172) and the Netherlands (A/AC.105/C.1/L.177).
2. The Subcommittee noted that studies of human physiology under the microgravity conditions of space flight had led to important advances in medical knowledge in such areas as the vestibular apparatus, blood circulation, biomechanics and metabolism. It noted that products of space biotechnology, such as pharmaceuticals, could have an important impact on health care on Earth.
3. The Subcommittee noted that space technologies were demonstrating growing promise in medical applications, most notably in the global monitoring of disease and in disaster relief. Airborne and space-based remote sensing technologies could permit the formulation of predictive models for the spread of vector-borne diseases such as malaria. The recent "Telemedicine Spacebridge" linking United States and USSR medical centres via satellite enabled consultations to assist the victims of the 1988 earthquake in Armenia. In addition, research in space would advance the biomedical sciences and improve quality of life on Earth. The techniques and lessons learned from these space-based activities could contribute substantially to educational programmes in these areas all over the world. The Subcommittee

endorsed the value of space for these purposes and encouraged Member States to study further the potential future benefits of these activities, perhaps in conjunction with the World Health Organization and other relevant organizations.

4. The Subcommittee noted that space studies in life sciences and medicine had important potential benefits for all countries and that efforts should be made to promote international cooperation to enable all countries to benefit from those advances.

5. The Subcommittee recommended that the Secretariat should prepare a study of medical technology that had resulted from research in space, based on information compiled from existing sources and information submitted by Member States.

6. The Subcommittee recommended that consideration of the item be continued at its next session.

VIII. PROGRESS IN NATIONAL AND INTERNATIONAL SPACE ACTIVITIES
RELATED TO THE EARTH ENVIRONMENT, IN PARTICULAR PROGRESS IN
THE GEOSPHERE-BIOSPHERE (GLOBAL CHANGE) PROGRAMME

(Contained in A/AC.105/C.1/L.175/Add.1)

IX. MATTERS RELATING TO PLANETARY EXPLORATION

7. In accordance with General Assembly resolution 45/72, the Subcommittee continued its consideration of this item. The Subcommittee heard a special presentation on the question by an expert from the United States, as mentioned in paragraph ... of the present report.

8. The Subcommittee noted that three planetary exploration missions were currently underway. The Magellan spacecraft was in orbit around Venus and conducting a systematic radar mapping programme. The Galileo spacecraft was on a complex trajectory to Jupiter, where it would make detailed observations of that planet. And the Ulysses spacecraft was on its long trajectory to observe the polar regions of the Sun. The Subcommittee also noted the plans for future spacecraft to study asteroids and comets and to conduct comprehensive investigations of Mars and Saturn. It noted in particular the high degree of international cooperation in all of those investigations.

9. The Subcommittee recommended that consideration of the item be continued at its next session.

X. MATTERS RELATING TO ASTRONOMY

10. In accordance with General Assembly resolution 45/72, the Subcommittee continued its consideration of this item. The Subcommittee heard special presentations on the question by experts from Spain and the United States, as mentioned in paragraph ... of the present report.

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11. The Subcommittee noted that the use of spacecraft for making astronomical observations from above the atmosphere had greatly advanced knowledge of the universe by allowing observations in all regions of the electromagnetic spectrum. It noted that with the launching of the Hubble Space Telescope, the Rosat x-ray observatory and the Gamma-1 and Granat astrophysical observatories, astronomers had powerful new tools for their investigations of the universe. The planned launches of the Gamma Ray Observatory, the Lyman Far Ultraviolet Spectroscopic Explorer (FUSE), the Radioastron satellite, the Spektr-Roentgen-Gamma observatory, the Advanced X-ray Astrophysical Facility, the Space Infra-Red Telescope Facility and the Infrared Space Observatory would open up further realms of the universe to detailed observation. The Subcommittee noted with satisfaction that all of those projects were open to broad international cooperation.

12. The Subcommittee recommended that consideration of the item be continued at its next session.

XI. THEME FIXED FOR SPECIAL ATTENTION AT THE 1991 SESSION:
"APPLICATIONS OF AIRBORNE AND SATELLITE REMOTE SENSING FOR PROSPECTING MINERAL AND GROUND-WATER RESOURCES AND FOR MONITORING AND MANAGING BIOLOGICAL RESOURCES, WITH EMPHASIS ON AGRICULTURE, TAKING INTO PARTICULAR ACCOUNT THE NEEDS OF DEVELOPING COUNTRIES".

13. In accordance with General Assembly resolution 45/72, the Subcommittee paid special attention to the theme "Applications of airborne and satellite remote sensing for prospecting mineral and ground-water resources and for monitoring and managing biological resources, with emphasis on agriculture, taking into particular account the needs of developing countries". The Sub-Committee noted with satisfaction that, at its invitation, COSPAR and IAF had organized a symposium on the theme on 20 and 21 February 1991. The Subcommittee expressed appreciation to COSPAR and IAF for the very instructive symposium. The Subcommittee took note of a working paper submitted by the USSR (A/AC.105/C.1/L.173).

14. The Subcommittee took note of the important contributions of satellite remote sensing for geology, including the use of radar systems for mapping large-scale geological structures, and the use of remote sensing to reveal linear features and multispectral anomalies associated with mineral, oil and gas deposits.

15. The Subcommittee also took note of the applications of satellite remote sensing to the development and management of water resources, including the monitoring of such factors as evaporation, vegetation patterns and surface water for planning and managing irrigation systems. The Subcommittee noted the effectiveness of the use of remote sensing in locating ground water for rural water supplies.

16. The Subcommittee also noted the applications of remote sensing for monitoring crop condition, evaluating changes in cropping patterns, estimating crop yield, monitoring drought conditions, planning the

expansion of cultivated areas, preventing and reversing land degradation, and monitoring deforestation.

XII. OTHER MATTERS

A. International Space Year - 1992

17. The Subcommittee noted that the General Assembly, in its resolution 45/72, had urged Member States and international organizations to consider supporting the efforts of the United Nations in connection with International Space Year (ISY), 1992. It also took note of information on the proposed programme for the participation of the United Nations in ISY (A/AC.105/445 and Add.1 to 4) and noted that a guidebook describing the programme had been distributed to Member States. The Sub-Committee noted that 1992 would also be the tenth anniversary of UNISPACE 82.

18. The Subcommittee noted that participation of the United Nations in ISY was to be through voluntary contributions and without any impact on the regular budget of the United Nations or the existing programme of work of the Programme. It also noted that the Secretary-General had sent a note verbale to Member States inviting additional proposals and voluntary contributions from Member States in support of United Nations activities as part of International Space Year. The Subcommittee expressed its appreciation to the Member States and international organizations that had made voluntary contributions to the United Nations Programme on Space Applications for this purpose or were planning to do so. The Subcommittee urged other Member States and international organizations to consider supporting additional scientific and technical activities in cooperation with the United Nations as part of International Space Year. The Subcommittee noted that it was particularly important to increase voluntary contributions for ISY activities to be carried out through the United Nations Programme on Space Applications as the Programme was dependent on voluntary contributions for most of its activities.

19. The Subcommittee considered that the activities to be undertaken by the United Nations and the specialized agencies as part of ISY should be complementary to the activities of international organizations such as COSPAR, IAF and the Space Agency Forum for International Space Year (SAFISY).

20. The Subcommittee noted the primary focus of proposed ISY activities on the use of space technology for studying and monitoring the environment. It noted that the General Assembly had endorsed the Subcommittee's recommendation that Member States, in planning their activities for ISY, consider ways in which those activities could complement the efforts under way for the Conference on Environment and Development, also planned for 1992. The Subcommittee recommended that the Secretariat of the Conference be invited to provide the Committee on the Peaceful Uses of Outer Space with information on the preparations for that Conference.

21. The Subcommittee noted the various national and international programmes being proposed as part of International Space Year and

heard special presentations on ISY activities by an expert from Brazil and by a representative of the Space Agency Forum for International Space Year (SAFISY). The Subcommittee noted the importance of including all countries in those programmes and of planning activities that would continue beyond 1992.

22. The Subcommittee requested the Secretariat to keep the Committee and the Subcommittee informed of further developments relating to this question.

B. Space and Earth environment

23. The Subcommittee noted that the General Assembly, in resolution 45/72, had recommended that more attention be paid to all aspects related to the protection and preservation of the outer space environment, especially those potentially affecting the Earth's environment.

24. The Subcommittee also noted that the General Assembly, in resolution 45/72, had considered that it was essential that Member States pay more attention to the problem of collisions with space debris, and other aspects of space debris, and called for the continuation of national research on that question. The Subcommittee noted that research relating to space debris was being carried out by Member States. The Subcommittee took note of a working paper on the subject submitted by Germany (A/AC.105/C.1/L.170). The Subcommittee heard a special presentation on the subject by an expert from India, as mentioned in paragraph ... of the present report.

25. The Subcommittee noted that there was a need for further research concerning space debris, for the development of improved technology for monitoring space debris, and for the compilation and dissemination of data on space debris. It also noted the importance of reducing the generation of space debris and of de-orbiting spacecraft after the end of their useful lives. It further noted the importance of international cooperation in addressing these issues.

26. The Subcommittee noted that the General Assembly, in resolution 45/72, had considered that space debris could be an appropriate subject for discussion by the Committee on the Peaceful Uses of Outer Space in the future.

27. The Subcommittee agreed that, at its next session, it would consider the question of including space debris as an item on the agenda of a future session of the Subcommittee. The Subcommittee also agreed that information on national research on space debris might be provided to the Subcommittee. The Subcommittee further agreed that specialists of Member States and COSPAR and IAF might be invited to make technical presentations, on an informal basis, on the results of such research at its next session, considering that 1992 is dedicated to the international efforts for the protection of the environment.

28. Some delegations expressed the view that the question of space debris should be included on the Subcommittee's agenda at its next session, allowing for a general exchange of views and information.

Other delegations, while recognizing the importance of the subject, expressed the view that such consideration was premature until further national research on the problem of space debris had been completed.

C. Other reports

29. The Subcommittee welcomed the annual reports of ESA (A/AC.105/464), INMARSAT (A/AC.105/466), EUTELSAT (A/AC.105/467), INTELSAT (A/AC.105/480) and INTERCOSMOS (A/AC.105/481), and the preliminary version of the thirtieth report of ITU on telecommunication and the peaceful uses of outer space. The Subcommittee requested ITU, ESA, EUTELSAT, INMARSAT, INTELSAT and INTERCOSMOS to continue to report on their work.

30. The Subcommittee expressed its appreciation to COSPAR for its report on the progress of space research during the period 1989-1990 (A/AC.105/479) and to IAF for its report on highlights of space technology during 1990 (A/AC.105/476). The Subcommittee noted that these reports might be published jointly for dissemination to a wider audience.

31. The Subcommittee noted with appreciation the participation in its session of representatives from United Nations bodies, specialized agencies and permanent observers, and found the reports/statements they had made helpful in enabling the Subcommittee to fulfil its role as focal point for international cooperation.

D. Review of the future role and work of the Scientific and Technical Subcommittee

32. The Subcommittee recommended that the agenda of its twenty-ninth session include the following priority items:

(a) Consideration of the United Nations Programme on Space Applications and the coordination of space activities within the United Nations system;

(b) Implementation of the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82);

(c) Matters relating to remote sensing of the Earth by satellites including, inter alia, applications for developing countries;

(d) The use of nuclear power sources in outer space.

33. The Subcommittee also recommended that the agenda of the twenty-ninth session include the following items:

(a) Questions relating to space transportation systems and their implications for future activities in space;

(b) Examination of the physical nature and technical attributes of the geostationary orbit; examination of its utilization and

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applications, including, inter alia, in the field of space communications, as well as other questions relating to space communications developments, taking particular account of the needs and interests of developing countries;

(c) Matters relating to life sciences, including space medicine;

(d) Progress in national and international space activities related to the Earth environment, in particular progress in the geosphere-biosphere (global change) programme;

(e) Matters relating to planetary exploration;

(f) Matters relating to astronomy;

(g) The theme fixed for special attention at the 1992 session of the Scientific and Technical Subcommittee: "Space technology and the protection of the Earth's environment: Development of endogenous capabilities, in particular in the developing countries and in the context of International Space Year".

34. The Subcommittee recommended that, regarding agenda item (d) in paragraph 29 above, COSPAR and IAF should be invited to arrange a special presentation on progress in the geosphere-biosphere programme. The Subcommittee further recommended that, regarding agenda item (g) in paragraph 29 above, COSPAR and IAF should be invited to arrange a symposium, with as wide a participation as possible, to be held during the first week of the Subcommittee's session, to complement discussions within the Subcommittee on the special theme.

35. Some delegations expressed the view that the task of the Subcommittee was to discuss policies and guidelines for international cooperation in space activities and to provide agreed technical parameters as a contribution to the development of international space law. While recognizing the significance of the scientific and technical presentations to the Sub-Committee, they expressed the view that the role of the Subcommittee as an intergovernmental body should be strengthened and enhanced and that the presentations should not interfere with its substantive work, which should have priority over such presentations.

36. With regard to the dates for the twenty-ninth session, the Subcommittee recommended that its session be scheduled from 18 to 28 February 1992.



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COMMITTEE ON THE PEACEFUL USES OF OUTER SPACE

DRAFT REPORT OF THE SCIENTIFIC AND TECHNICAL SUB-COMMITTEE ON THE WORK OF ITS TWENTY-EIGHTH SESSION

Addendum

IV. USE OF NUCLEAR POWER SOURCES IN OUTER SPACE

The new paragraphs given below are to replace paragraphs 11 to 13 of document A/AC.105/C.1/L.175/Add.1:

1. The Subcommittee noted that the scientific and technical guidelines and criteria for the safe use of nuclear power sources in outer space could, in the future, be reviewed and revised as necessary, as provided in principle 12 of the draft principles contained in document A/AC.105/C.2/L.154/Rev.7.
2. The Subcommittee took note of the work being done in the IAEA and other international organizations concerning international principles of radiation protection. The Subcommittee noted that its recommendations on principles for safe use of nuclear power sources should appropriately reflect any relevant international guidelines and standards dealing with nuclear power sources, including those of the IAEA and other international organizations.
3. The Subcommittee took note of a working paper submitted by the United States (A/AC.105/C.1/L.176), that, according to that delegation, revisited certain portions of the Subcommittee's recommendations underlying draft principle 3, with a view to the Subcommittee's making specific modifications to ensure the technical accuracy of the recommendations, as a step towards contributing further to the substantial progress made in the Subcommittee on this subject.
4. In this connection, some delegations expressed the view that, in the consideration of the draft principles, discussion of principle 3 should not be re-opened. Work should continue on the remaining principles on which agreement has not yet been reached.



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COMMITTEE ON THE PEACEFUL USES
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Scientific and Technical Subcommittee
Twenty-eighth session
Agenda item 7

USE OF NUCLEAR POWER SOURCES IN SPACE

Working paper submitted by the United States of America

As this Subcommittee continues to work towards finalizing deliberations on the use of nuclear power sources (NPS) in outer space, and as the Legal Subcommittee moves towards consensus on a full set of draft principles on NPS, the United States believes that it is incumbent on both Subcommittees to ensure that any complete set of recommendations or draft principles is as credible as possible in the light of current technical understanding.

In the United States' view, it is also of the utmost importance to ensure that consensus recommendations, as they have been reached in this Subcommittee, or draft principles, as discussed in the Legal Subcommittee, fully reflect the understanding of the participants in those discussions on those recommendations or draft principles. With these objectives in mind, the United States wishes to review significant aspects of its NPS activities as they relate to the implementation of safety principles. We also wish to state clearly, for the record, the United States' interpretation of certain provisions now contained in the draft principles. Finally, we wish to propose and explain certain changes to the language of the principles which we believe will enhance their value.

This is offered not only to deepen Member States' understanding of space nuclear power generally, and United States practice in particular, but also to continue constructive progress towards a set of final recommendations in this Subcommittee and, ultimately, a set of final principles in the Legal Subcommittee on NPS.

United States NPS activities

The United States continues to believe that space nuclear power has an important role in the use and exploration of outer space. Historically, the United States has followed the practice of employing stringent design and operational flight safety measures to protect the public and the environment under normal operations and postulated accident conditions. In addition, as NPS are considered for use in particular missions, they undergo intensive, open and publicly available safety analyses to establish the potential risks under credible operational or accidental circumstances.

The United States environmental review process is conducted in compliance with the National Environmental Policy Act of 1969. As mandated by that law, the environmental consequences of selecting an NPS (over a non-nuclear power source), as well as engineering, economic and safety considerations, are weighed before final launch approval. The Act requires consideration of a broad range of topics, including potential environmental, socio-economic and cultural impacts as they may pertain to humans, flora and fauna. The environmental impact evaluation process includes formal opportunities for input by the general public and has evolved into a significant and effective method of informing the public about proposed NPS launches and any environmental consequences thereof.

Each United States agency involved in the use of NPS in space has its own regulations that are based on overall Federal regulations regarding exposure to nuclear radiation. The United States practice is one of developing detailed criteria, specifications and requirements for agency use in a top-down approach, beginning with overall Federal regulations and guidance. Furthermore, the emphasis is on line management responsibility for safety with independent oversight at the various levels of line management. Safety is a principal driver in the design of the nuclear heat source in an NPS for use in outer space.

Finally, there is an overall nuclear safety review conducted by an independent inter-agency nuclear safety review panel (INSRP) prior to the proposed launch of an NPS. The INSRP works under a presidential directive and agency guidelines to conduct a safety review for each planned mission. The panel does not make a recommendation of launch approval or disapproval. Rather, it provides an independent evaluation of radiological risk to the decision-makers who must weigh the benefits of the mission against the potential risks. Panel members review safety analysis reports, as they are prepared by the Department of Energy, for information such as impacts on human health and safety as well as other sources of pertinent information. The panel prepares a safety evaluation report containing an independent assessment of launch and flight risks, which is then submitted to the Executive office of the President, as part of the request for nuclear safety launch approval.

The primary safety design objective for both radioisotope and reactor power sources is to minimize the potential interaction of the radioactive materials with the public and the environment. In the case of radioisotope thermoelectric generators (RTGs), this objective leads to a design philosophy of containment, immobilization and recovery of the nuclear materials.

As in the case of RTGs, safety has been the principal driver in the design of the SP-100 reactor power assembly under development in the United States. Consistent with overall United States safety criteria, this reactor is designed to prevent inadvertent criticality during handling or in postulated accident conditions. The keys to SP-100 safety may be summarized as follows:

- The reactor will be launched "cold" (i.e., no significant radioactive fission products and non-operation);
- The reactor is designed to prevent accidental start-up during launch and ascent;
- The reactor is started only after achieving the safe operating orbit;
- The reactor is designed to prevent inadvertent criticality through the use of two independent reactor shut-down systems;
- The reactor is designed to remain in, or be boosted to, high Earth orbit after operation;
- Even though the reactor is designed to remain permanently in space, it has been designed to safely accommodate postulated accidental re-entries and impact.

United States views and recommendations relating to NPS

Since the beginning of the Subcommittee's deliberations on NPS, the United States has been supportive of the Subcommittee's work on clarifying the scientific and technical aspects of the safe use of NPS in outer space. Indeed, we are hopeful that the work in this Subcommittee can lay a solid technical foundation for consideration of principles in the Legal Subcommittee. In this regard, the United States believes that the Subcommittee has an obligation to ensure that consensus recommendations are both scientifically and technically sound. Only in this way can this Subcommittee's work find its fullest meaning in final principles.

In the United States' view, the Subcommittee should not retreat from the difficult task of ensuring that the highest scientific and technical standards are met in every one of the recommendations developed. Rather, we should welcome the opportunity. Ultimately, any principles based on our recommendations will only be as strong as the recommendations themselves.

It is in this spirit that the United States proposes to revisit certain specific portions of the Subcommittee's recommendations underlying what is now termed principle 3 in the Legal Subcommittee. It is our objective to enhance their technical credibility.

Some of the recommendations proposed here would not require any changes to the language adopted in the report of the Scientific and Technical Subcommittee's 1990 Working Group on NPS (A/AC.105/456, annex III). There are other recommendations

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which we believe should be adopted but which will involve changes in the language adopted in the report of the Subcommittee's 1990 Working Group on NPS and draft principle 3.

Regarding the opening paragraph to principle 3, we believe that it is appropriate for all the principles to stress that the use of nuclear power sources should be based on technical needs with full consideration of safety and environmental concerns. It is, however, incongruous for one principle to have its own preamble. We propose deleting the paragraph and having an appropriate statement on this idea in an overall preamble. We will suggest specific language in time for the next Legal Subcommittee meeting.

Throughout the recommendations, "shall" and "must" should be replaced with "should". In our view, this is clearly consistent with the non-binding, recommendatory nature of the principles.

We would also recommend that another clarification be made throughout the text, replacing the word "foreseeable" with the word "credible". The United States safety assessments which cleared the Ulysses and Galileo spacecraft for launch limited the universe of hypothetical accident scenarios to those with reasonable probability of occurrence. This set of scenarios was thus labelled as "credible". The United States change brings the usage in the recommendations into conformity with this established formulation.

The United States proposes that the concept of dose limits be re-examined and recommends that paragraph 1.3 of the 1990 NPS Working Group's recommendations (A/AC.105/456, annex III, sect. III, para. 15) be modified. We recommend substituting the following language for the current second and third subparagraphs:

"Except in cases of low probability accidents with potentially serious radiological consequences, the design for the NPS systems should [shall], with a high degree of confidence, restrict radiation exposure to a limited geographical region and to individuals in the public to risks (probability of exposure times consequence) which are as low as reasonably achievable."

In the United States' view, this modification, by taking into account the probabilistic concept of risk, which is a central feature of a thorough safety assessment, relates the recommendation directly to the well-proven space NPS practices of the United States.

A similar type of clarification is recommended for the first two sentences of part 1.4, to read:

"Systems important for safety should [shall] be designed, constructed and operated in accordance with the general concept of defence-in-depth, as appropriately adapted for space nuclear systems. Pursuant to this concept, credible [foreseeable] safety-related failures or malfunctions must be compensated for by design or capable of being corrected or counteracted by an action or a procedure, possibly automatic".

We believe that this clarification removes any doubts as to the intent behind the application of the term "defence-in-depth". Without this clarification, the paragraph could be read to apply to space systems, a terrestrial nuclear term of art that embodies design approaches which may be technically unfeasible in space. We are convinced that the Subcommittee did not, in its earlier recommendations, intend to apply the terrestrial standards as such to space systems. The second sentence of part 1.4, as it now appears, makes no provision for passive systems, such as RTGs, or for the preferred solution, in the case of either passive or active systems, of countering risks by system or mission design. The refinement proposed by the United States contributes materially to the completeness of the paragraph.

Related to the proposed modifications to the reference to "defence-in-depth", the United States believes that the current use of "inter alia" in subparagraph 3 of 1.4 should be clearly understood. We note that in subparagraph 1 of 1.4 in A/AC.105/456, annex II, section III, the term "for example" precedes the recommendation that successive barriers are considered. It is our view that, in subparagraph 3 of 1.4 in A/AC.105/456, annex III, section III, as well as in paragraph 1.4 of principle 3 as it appears in annex I to the 1990 report of the Legal Subcommittee (A/AC.105/457, annex I, para. 12), "inter alia" should be replaced with "for example". It is our view that there need not necessarily be other means of ensuring reliability beyond those listed in the remainder of the sentence, or that any or all of those listed must be employed in a given NPS. The United States expressed this view in joining consensus on principle 3 in the Legal Subcommittee and wishes to reconfirm that view here.

The United States believes the Subcommittee's intent in paragraph 2.4 was that NPS would not be operated at power for sustained periods of time so as to generate a meaningful radionuclide inventory. Zero power critical testing is an important part of launch safety that does not produce significant radionuclides. Without such testing, NPS would be less safe. Therefore, the following language is suggested for paragraph 2.4.

"Nuclear reactors should [shall] not be made critical during or after launch until [before] they have reached their operating orbit or [interplanetary] trajectory."

Finally, the last clarification we would recommend involves paragraph 3.2 of A/AC.105/456, annex III, section III, which also appears as paragraph 3.2 in annex I to the 1990 report of the Legal Subcommittee (A/AC.105/456, annex I, para. 12). The United States believes that the paragraph should read

"Except for low probability occurrences, the nuclear fuel in radioisotope generators should [shall] be protected by a containment system that is designed and constructed to withstand the heat and aerodynamic forces of re-entry in the upper atmosphere under credible [foreseeable] orbital conditions [including highly elliptical or hyperbolic orbits where relevant]. Upon impact, the containment system and the physical form of the isotope should [shall] ensure that any radioactive material scattered into the environment is localized, so that the impact area can be [completely] cleared of radioactivity by a recovery operation."

/...

The first change is intended to take into account the fact that the probability of accidental re-entry from hyperbolic or highly elliptical orbit can be reduced to a very low value by mission design and operations. The change in the last sentence is in recognition of the fact that the practical design objective for RTG containment systems is localization rather than zero release under all circumstances, and that there are practical limits from a cost-versus-risk standpoint on "complete" clearing of radioactivity by a recovery operation.

Summary

The United States wishes to emphasize that these proposed clarifications and modifications to the Subcommittee's recommendations are offered in a constructive spirit. We are seeking to contribute further to the substantial progress made in the Committee on NPS. We view these proposed refinements as steps towards a meaningful set of recommendations that are based on sound scientific and technical findings. Ultimately, any principles adopted on the basis of this Subcommittee's recommendations will only be as strong as the scientific and technical merit behind them. It is with this in mind that we respectfully submit these remarks for the Subcommittee's consideration and for delegations' comments.



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Agenda item 10

MATTERS RELATING TO LIFE SCIENCES, INCLUDING SPACE MEDICINE

Results of space-related research in the Netherlands

Working paper submitted by the Netherlands

Coordination of the activities related to space science is a task conducted by Space Research Organization Netherlands (SRON). Several institutes have programmes in which some kind of research related to space is performed.

Recently no medical experiments in outer space have been conducted. Space science related medical studies were done at the following institutes:

Institute for Perception, Soesterberg (Dr. W. Bles,
Dr. J. T. Marcus)

Vestibular physiology is the main theme.

1. High g-load effects were studied in former European Space Agency (ESA) astronauts with the goal of gaining more insight into the development of space sickness. This project was done in close cooperation with the Technical University Delft (Aviation Department) and the University of Amsterdam (Medical Faculty, ENT Department).

Results. A hypothesis was published about the genesis and development of space sickness.

2. Vertical eye movements were studied in humans subjected to accelerations in the human centrifuge.

Results. A vertical nystagmus accompanied by rumbling sensations points to a specific stimulation condition of the vertical canals.

University of Amsterdam, Medical Faculty, Department of Internal
Medicine (Dr. J. M. Karemaker, Dr. W. Wieling)

Blood pressure measurements. Blood pressure was measured with a recently developed device, the finis press, which is able to acquire information from a subject's finger.

Results. During parabolic flight, blood pressure changes were measured in human subjects. In upcoming experiments, the device will be used and the blood pressure profile will be subjected to further studies.

Department of Otorhinolaryngology (Prof. Dr. W. J. Oosterveld,
Dr. H. A. A. de Jong, Dr. H. W. Kortschot); Section:
vestibular system

Four experiments were conducted in ESA's parabolic flight campaign at Brétigny, France, with the use of the Caravelle 234.

1. Vestibular tests during weightlessness

The mechanism of the caloric test, which is clinically of great importance, is not yet clear. This test was performed during weightlessness in human subjects in parabolic flight. The test was carried out in different head positions of the subjects in order to define an optimal test procedure.

Results. The horizontal and vertical components of a caloric-induced nystagmus were studied during parabolic flight. Human subjects were tested in three different positions. In inflight calorizations, the water irrigation was finished just before the start of the pull-up of the manoeuvre of the aircraft. Thus the first period of weightlessness took place during the optimum caloric response, 60-90 seconds after the start of the irrigation.

- Both horizontal and vertical nystagmus components decreased or faded away completely during the microgravity period;
- These components recovered during the pull-out and reached values similar to the ones found during the pull-up;
- In prone position (face down) in all tests, the subjects showed a direction of the horizontal slow nystagmus component opposite to that found in supine position (face up);
- The decrease and disappearance of the caloric vestibular nystagmus during short-duration microgravity does not require additional sensory influences.

In several test subjects, the horizontal and vertical components of the caloric nystagmus showed a different time course. Thus further investigations on an additional influence of the vertical canal and/or otolithic sensory system are required.

2. Pupil size measurements during weightlessness

Studies in animals have shown that in some species neurological pathways exist between the balance organs and the ocular muscles which serve pupil dilation and constriction. The meaning of this structure is not known. The pupil size was measured both during weightlessness in parabolic flight and during high g-load experiments in a human centrifuge.

Results. The experiments made clear that "vestibular ocular" pathways most probably exist in humans as well, connecting the nucleus of Edinger Westphal with the vestibular nuclear complex. With these results the close relationship between vision and such vestibular symptoms as vertigo and dizziness became more clear. The theory was further supported by findings in experiments at the ESA Space Sled at the Institute for Perception (Soesterberg) and with the aid of a human centrifuge (Netherlands Institute for Aviation and Space Medicine, Soesterberg).

3. Cervical column

Movements of the cervical column are able to induce vertigo in man. This is assumed to be caused either by signals from pressure-detecting devices in the cervical muscles or by direct gravitational effects on the cervical nerve roots.

An investigation was carried out with human test subjects who had to make special head movements according to a special programme in the weightless periods in parabolic flight. Most probably, pressure devices in the cervical muscles are the main source of signals during head movements with a fixed head. Under normal gravity conditions, vascular components as well as irritation of the cervical nerve roots also play a role. In microgravity these two components diminish while the action of the pressure devices becomes more imminent.

A rotation chair programme was conducted in parabolic flight. The body was rotated in the horizontal plane with a fixed head.

Results. The cervical pressure devices in the muscles proved to be the main component in eliciting cervical-induced movements and vertigo. For clinical test procedures, the method described above will be further developed to gain extensive information about the condition of the cervical structures in patients suffering from cervical-related vertigo and balance disorders.

4. Swimming behaviour of fish in weightlessness

Fish belong to those species on Earth accustomed to life in a real three-dimensional spatial environment where gravity is the only reference for orientation. This makes the fish a unique test animal for behaviour studies in low-gravity fields.

Experiments in parabolic flight were conducted in three different conditions:

- (1) Normal fish, species goldfish;

(2) Blind fish (Anophtichtus jordani) which lack a visual system as a component in their orientation system;

(3) Fish which have been operated upon so that they are artificially blinded.

Results. Preliminary results show that for fish the vestibular organs are extremely important, perhaps even the most important component in swimming behaviour, as well as in positioning activities with regard to the direction of gravity. To explore the importance of the vestibular components in relation to each other as well as the consequences of circumscribed lesions in the system, a protocol has been designed for experiments in the ESA parabolic flight campaign.
